THE CREATION OF MATTER

OR

MATERIAL ELEMENTS, EVOLUTION, AND CREATION

THE CREATION OF MATTER

OR

MATERIAL ELEMENTS, EVOLUTION, AND CREATION

THOMSON LECTURESHIP TRUST

BY

REV. W. PROFEIT, M.A.
GLENBUCHAT

IMPORTED BY
CHARLES SCRIBNER'S SONS
NEW YORK

PRINTED BY
MORRISON AND GIBB LIMITED,
FOR
T. & T. CLARK, EDINBURGH.
LONDON: SIMPKIN, MARSHALL, HAMILTON, KENT, AND CO. LIMITED.
NEW YORK: CHARLES SCRIBNER'S SONS.

INTRODUCTION

The greatest questions which man can ask and attempt to answer belong to the sphere of origins. We live in the midst of perpetual motion and change, and see all things flowing around us without ceasing. Are they as a river proceeding from a source and running towards a goal? Are they as a sea swaying to and fro, for ever to and fro; or as a whirlpool circling round and round, without beginning or end? Have they existed from eternity as they are now; or have they assumed their present form by chance aggregation, combination, and development; or have they been built up out of eternal matter by an eternal mind arranging, uniting, constructing; or is matter itself the work of mind? Natural theology, arguing from design, has hitherto only set itself to prove that the great kosmos in the midst of which we find ourselves has not existed from eternity as it now is, has not been formed by chance, but has been arranged and built up by a mind of immeasurable power. We propose to address ourselves to the last question, and to show that matter is the creation of mind; that in its primal elements, however far back we may have to go to find them, there are so many signs of mind as to render it evident that they are the product of an understanding that is infinite, of a hand that is omnipotent. We must, in the first instance, deal with the simplest forms of existence as at present known

to science, show the riches of order and potency revealed in them by their many and varied evolutions, and then it will not be difficult to see and conclude that if these be evolved from simpler primals, these primals have been made, and so have, being primal, been created.

The subject therefore we propose to discuss in the following lectures is Material Elements, Evolution, and Creation.

Material elements consist of the atoms and molecules of ordinary matter, and an ether, that fills all known space, and is the medium by which light and heat motions and electrical states are conveyed from place to place, from sphere to sphere.

The term of evolution is appropriate in every field of science. Chemical compounds, as water, salt, sugar, are evolutions by combination from simpler atoms. Light and heat, life and complex organisations, are evolutions. Darwin's great theory has by some been presented as if it gave a sufficient account of all forms and complexities of being and of the manner of their becoming. Step by step during the ages of ages the elements have of themselves built up the universe. Gradually and slowly they have marched onward and upward, taking ages for single steps, until they have reached heights of sublimity and heavens of order, and crowned their work in natures capable of investigating it with eyes of intelligence, and of ascribing to it glory in the highest.

The most effective way of meeting this contention, which has troubled many minds, is to study the elements as they are revealed in their various evolutions, and to show that their operations are everywhere guided by mind, and that they are so richly and exquisitely endowed and ordered, that their existence must be due to a great understanding.

Creation deals with questions as to the ground of being of the elements themselves. Are they self-existent? Have they existed from eternity? Have they known a beginning? Have they been evolved from simpler primals? Have the primal elements, wherever they may lie, been created? It is, as we have said, our purpose to show that to a creating hand their existence is due. But first we must consider the doctrine of signs and signs of mind.

CONTENTS

X. THE EVOLUTION OF SPECIES

XI. CONCLUSION

THE CREATION OF MATTER;

OR

MATERIAL ELEMENTS, EVOLUTION, AND CREATION

I

SIGNS AND SIGNS OF MIND

The Doctrine of Signs—Indirect—Direct—Signs of Past Action—Intelligent Natures—Mind *on* Matter—Matter an Ideal Form of Being for revealing Mind—Human Fashioning—Power of Mind in Proportion to the Signs—Signs on the Dispositions and Organisations of Matter—On Matter itself—All Matter ordered.

WHATSOEVER we are conscious of, or become acquainted with, in ourselves, in the heavens above, or on the earth beneath, hath its signs by which it reveals itself. By signs the consciousness of our own existence is awakened and maintained, the knowledge of our own nature and powers is acquired. By signs external nature presses in upon us and compels us, willing or unwilling, to acknowledge its presence, to do homage to its every characteristic. It creates in us a thousand, ten thousand, sensations of great variety, and of every degree of energy. And every

sensation is a sign. Every sensation has its meaning. It speaks of relationship to us, of a power in things to affect us; and according as they affect us we judge of their nature, we ascribe to them their characteristics. And wherever we perceive the same signs we infer the same meanings, we draw the same conclusions. The same signs in the same circumstances—and unless the circumstances be the same, all the signs are not the same—the same signs, we say, proceed from the same substances, speak of the same natures.

Every distinct object is characterised by its own qualities, powers, and appearances, and by them may be distinguished from that which is characterised by different qualities, powers, and appearances. It is easy to recognise light when we see it shining, fire when we perceive it flaming and feel its heat. Every element in nature, or combination of elements, has its signs by which it proclaims its presence, and says, "It is I that am here." It is easy to say of one substance, "It is iron"; of another, "It is gold." Oxygen has its signs; hydrogen, nitrogen, carbon, chlorine, iodine, phosphorus have their signs. These signs no chemist distrusts; his science is built on them. He works in their midst with confidence; he depends on them, and is not disappointed. All the sciences have the same foundation. Every stone or rock has its signs by which it can be known. Every plant has its characteristics by which it can be distinguished. Every animal has its marks by which it can be classified. The laws of sound, light, heat, and electricity are learned in the same manner. What are laws but substances or elements acting alike, showing the same signs?

The sciences glory in truth. Their votaries boast, and justly, of the certainties which alone they permit to settle in their fields. They seek truth in a scientific manner.

They investigate carefully. They conduct their researches accurately. They collect facts; they classify them. They make experiments. They deduce laws. They form theories. They test them. They prove them. They pass them through the fire till they come forth as gold. And the results of scientific work are magnificent. The structures which science has built up are of supreme grandeur. They have revolutionised the world. They have advanced and glorified civilisation. They have scattered wonders among the nations, brought them to the doors of the peoples, quickened their life, elevated their intelligence. And the whole work of science is the study of signs. It is the interpretation of their meaning. Its truths and laws are inductions from them. They are signs generalised. And science has no hesitation, when it perceives the clear signs of the presence and action of any substance and force, in saying that that entity and force are or have been present. There are circumstances in which the conclusion is that they are present; there are circumstances in which it is that they have been present. They have been present, for they have acted. They have left their marks, they have imprinted their characteristics, they have impressed their seal and image.

The science of geology is built on the signs of the *past* action of forces; it endeavours to read the meaning of the present condition of the crust of the earth, the meaning of the phenomena now existing, and to come to conclusions as to the causes which operated before the ages and generations in producing those phenomena. Here, they say, are the signs of the operation of water; these are water-formed rocks. Here are the signs of the operation of fire; these are fire-formed. And so when the Dervish was asked, "How do you know that there is a God?" he answered, "How do I know that it was a

camel, not a man, who passed my tent last night? By the footprints," was the reply. Pointing to the sun, he said, "That is a footprint, and not of a man but a God." How easily we may know in the morning, after a time of drought, that rain has fallen in the night, and after rain that a cycle, a waggon, a two and a four wheeled machine, a man and a flock of sheep have passed along the road. Rain has fallen plentifully, for the ground is soaked. A cycle, a waggon, and machines have been on the softened surface, for each has left its distinctive track. A man and a flock of sheep have gone on before them, for the footprints are clear, and of the latter there are many. The signs are as certain as if we had seen the various objects soaking the ground, making the tracks, printing the footsteps. And it is our purpose to show that the signs of mind on matter are as clear and distinct, as trustworthy and certain, as if we had seen the Eternal Mind marching in majesty through space, leaving suns and planets behind Him as His footprints; as if we had been endowed with vision and understanding so powerful as to be able to see them in their magnitude, and comprehend at a glance the order kindled in every particle. We have had experience of the former signs, it may be said, but not of the latter. But the latter are more distinctive and clearer in meaning, more trustworthy and certain, than the former, for they are in the very nature of things, and that which is in the nature of things is more to be trusted than all experiences.

From *whatever distance* also in the heavens a sign comes, it is received without distrust; unlimited faith is placed in it; its truth is never questioned; its message and interpretation obtain a settled place among the verities of science. One of the most wonderful discoveries of modern times is that of the lines in the

spectra of various substances burning. When sodium is burning in a flame a bright line appears in the yellow part of the spectrum. Potassium gives two bright lines, one at each extremity. Strontium places its special signs in the blue and orange, and six less distinct ones in the red portion. Each substance has its own lines, and scientists, when they see them, at once and confidently affirm that the corresponding substances are present. New elements have been discovered by means of lines otherwise unaccounted for. From whatever source the light proceedeth, though it come from the most distant stars, when certain lines are seen, there is no hesitation in inferring that the elements which those signs represent are in the flames of those stars. The presence of $\frac{1}{180}$ or $\frac{1}{200}$ millionth of a grain of sodium is sufficient to print its characteristic line. A portion of lithium, less than $\frac{1}{6}$ millionth of a grain, can thus be detected. A large number of elements have in this manner been proved to exist in the sun's atmosphere.

Mind has signs by which it makes itself known. It shines in the human countenance; it beams in the starry eye; it speaks in the tones of the voice and in words of wisdom; it shows itself in skilful work. The face of idiocy is easily recognised. The lack-lustre eye is quickly understood. A meaningless voice and words tell their own tale. A shapeless mass, rude disorder, blundering workmanship, proclaim loudly what they lack. In animals there is a measure of intelligence, as in the ox that knoweth his owner, in the horse that will find his way when the rider faileth. Wherever mind is present in any existence, it acts with intelligence, it operates in an orderly manner. It thinks, it plans, it measures, it weighs, it shapes, it numbers; it locates, adjusts, adapts, arranges, and builds up complex unities; it forms same-

nesses, likenesses, harmonies, analogies; and wherever we see any form of being possessing in itself the power of doing these things, we cannot but ascribe intelligence to it.

Matter is matter and not mind, and cannot therefore show the same signs, do the same work. Every form of being must act according to its nature. That which is in it to do, it can do. That which is not in it to do, it cannot do. Matter has its own nature and properties, and can act according to them. But the particles of matter have not in them conscious intelligence, and consequently have not of themselves the power of arranging and so of producing complex order. It is mind and mind only, this form of being and none besides, that can do such work. If any entity in its action manifest clear signs of mind, it must itself possess it or be directed by it.

Matter can receive and show signs of mind *on* it. Not having intelligence in itself, it is specially fitted to reveal it outside itself, moulding and fashioning it, and leaving it moulded and fashioned and laden with clearest signs that mind has been operating upon it. Particles being powerless to think, choose, and determine their own and each other's characteristics and modes of being and action, so as to have measures and relationships to each other, are the best form of existence on which mind may exercise the variety of its powers, manifest itself, and unfold its glories. They are what they are by no thought of their own, by no intelligence in themselves, and therefore of necessity the order found throughout their borders must be accounted for by postulating an intelligence external to them. Matter, therefore, as being material in its nature, is an ideal form of being for revealing mind, for revealing the Eternal and Infinite Mind.

Material substances—wood, stone, gold, silver, iron—

wrought upon by human skill are made to assume forms of beauty and usefulness. Implements of agriculture, machinery at the service of every industry, mighty engines, inventions without number, inventions which delight us by their simplicity and ingenuity, or by their complex order concentrated and directed to one end, houses, mansions, churches, cathedrals, works of painting and sculpture, these are the magnificent fruits of the working of the human mind on the matter of our globe.

And everywhere signs of mind on material objects are due to mind. Scientists act on this principle. Were it possible for a geologist to find in a stratum of the earth's crust a comb of wax, or a beaver's lodge petrified, would he not at once affirm that living creatures of the same nature and intelligence as now produce such works existed on it in the age to which the stratum belonged? Were he to find, we do not say a brilliant invention or a complex machine, but a few arrowheads or rude axes, would he not quickly affirm them to be the work of man? A wonderful system of lines has been observed on the planet Mars. They are like canals, and, says Sir Robert Ball, "they often show such a degree of regularity as would almost suggest the idea that they had been laid down by intelligent guidance." The scientist cannot but interpret signs of mind even as all other signs. No one, in short, when he sees the clear marks of the working of any nature and force, can do otherwise than admit that there that nature and force have wrought; when he sees the results of the working of fire and water, that there fire and water have been operating; and so in like manner when we see clear and distinct marks of intelligence engraven on any object, it is impossible not to draw the conclusion that there intelligence hath presided at the engraving.

The powers of mind operating must be according to the signs. The signs of it in its working may not reveal it always in the fulness of its strength, but it must be of a power sufficient to produce its greatest works. It requires an eye and mind to do the least ordered work, an eye and mind to plough the fields. A single straight furrow is sufficient to make evident that it hath been cut and laid by intelligent guidance. It cannot be produced by haphazard. Fields to which the masters of the craft have gathered, and in which they have put forth their strength and care, are a sight to see, so equal in every respect, so finely laid, are the furrows.

Looking on the ploughman at work one imagines that there is no difficulty in producing at least fair results, that there is little to do but put to the hand and hold fast. But, *crede experto*, believe one who has tried. All was going well; the horses were moving forward with staid dignity, the plough behaving unto perfection. I went forward, and in my simplicity put to my hands. But what ailed the plough? Had an evil spirit entered it? In a moment it was out, running on the surface. A desperate effort got it into the soil again, but so deep that it could not be moved at all. The rectification revealed another peril: the furrow became so broad that it could not be turned over; and in the effort to set that right, it became so narrow that there was nothing to turn over. In like manner it needs an eye and mind to shepherd the sheep, to plane the board, to shoe the horse, to copy with the pen, to guide the locomotive. It requires higher intelligence to shepherd the people, to be a great statesman, a brilliant strategist, to produce the works of Homer, Plato, and Newton, the statues of Phidias and Michael Angelo, the masterpieces of the greatest painters, to exhibit architecture like St. Paul's Cathedral, to produce

works involving arrangements, proportionings, and calculations, as in the great railway bridges over the Tay and Forth. There is no labour on earth that does not need an eye to see and a mind to think. There is no work, nor device, nor trade, nor profession, that does not require a great amount of teaching and practical training to ensure an approach to perfection. Ordered work cannot be done save by trained intelligence equal to its production.

The signs of mind in nature go far beyond those which appear in the works of man. They are on a greater scale. They cover vaster fields. They are more wonderful, more brilliant, and demand immeasurably greater power of mind, than any produced by human intelligence.

There are many clear signs of mind in the dispositions of matter and in its organisations. Linnæus, being rallied by a friend on his devotion to science, laid his hand on the ground and said that underneath it there was as much as would worthily occupy a human mind for a lifetime in becoming acquainted with it. The earth is filled, and overflows with the glories of mind. Every blade of grass beams with it. Every common bush is afire with it. The fowls of the air, the fish of the sea, the beasts of the field glow with the brightness of its shining. Man is its crowning splendour. The heavens declare its glory. Sun, moon, and stars are radiant with it, with a brilliancy eclipsing their own. We are encompassed by it as by a sea of lights. We are steeped in it, bathed in it. In this field the natural theologian has at his service, open to every eye, within reach of the knowledge of every intelligent mind, a great variety of organisations rich in complex and perfect order, and marvellously adapted for their place in nature.

In the argument before us, we have not the facts on

which we ground our reasonings so plainly before the eye, so easily within the reach of the knowledge of all men, as in the former case. They are somewhat behind the scene; they are covered over. Or if they lie, as some of them do, on the surface, they are not so striking. They do not so easily produce their full impression, proclaim all their meaning. Their meaning is not on the surface. They hide their splendour. They dwell deep. We must therefore dig for them, as for gold; search for them, as for treasures; dive for them, as for pearls. We must put forth our strength, and bend our mind eagerly and earnestly to the task. And as it is when men dig deep that they secure the richest treasures and reach adamantine rock, so it is when we go down to the elements of matter and consider them that we reach the greatest truths, and a knowledge of them and confidence in them that cannot be shaken, that cannot be undermined.

In our argument, we propose, as we have said, to show that all matter is composed of ordered elements, and that the order is due to mind. It is not a chaos. It does not consist of substances inert, of particles separated from each other by differences many as their own number, particles without likeness, measure, relationship, or any ordered characteristic. Had it done so, it would not have formed a subject of knowledge. Laws of action could not have been predicated of it. No general affirmations could have been made regarding it, or any portion of it. The mind could have done nothing with it, would have found nothing characterising it to think about, nothing of its own kind of operations to see and to understand, to class and to name. It would have presented no field for scientific investigation, but would have been a barren desert, a region of darkness, *rudis indigestaque moles.* A science of chemistry, of physics,

of any kind, would have been impossible. But it is not so with matter. It yields itself easily and spontaneously to distribution into divisions, placing this particle in this division, that particle in that division, and every particle in some division. Not merely a select few, but all material particles, may be scientifically examined, their qualities determined, and, according to measured likenesses and differences, placed among their kind, every one of which they in every respect resemble. Of all kinds, many general statements may be made. Of each kind, many affirmations may be advanced, announcing the laws of their action and the properties distinguishing them. They thus open up large fields for scientific investigation, in which an immense wealth of knowledge may be reaped. In short, matter in itself is full of thought. It is crammed with ideas. It is a scene, extending before the mind beyond all limits, and radiant with adjustments, adaptations, and arrangements. It is full of thoughts which we can think. It is crammed with ideas which we can apprise and enthusiastically admire. It is radiant with adjustments, adaptations, and arrangements which we can measure, classify, and name. Its condition is ideal. Its order, as it reveals itself, thrills the investigator. Every discovery is a prize to the discoverer, is a rapture, and moves him almost irresistibly to cry out, εὕρηκα, εὕρηκα, I have found, I have found. What, then, has thought the thoughts and carried them out? What has conceived the ideas and realised them? What has invented the adjustments, adaptations, and arrangements, and shown them working unto perfection on the fields of fact? What has imparted to all matter its ordered condition, made it the mind's delight, the understanding's rapture? Not matter itself, not the abstract thoughts and ideas. For thoughts cannot spring where mind is not, much less

can they be carried out; ideas cannot be formed where there is no understanding to form them, much less can they be realised; adjustments, adaptations, and arrangements cannot be devised when there is no devising nature, much less can they be produced. These are not workers, but the work done. A perceiving mind, great as the greatness of the work, has imparted to matter the dazzling order which distinguishes it.

It will not be difficult to see where mind has been at work on matter. The marks of its hand it will be easy to distinguish. It prints its footsteps brilliantly. Its work is inimitable. We can imagine in some cases different physical substances and forces leaving behind them traces very difficult to differentiate. But what save mind can do the work of mind? What can fill its place, produce its effects, and show its sail of glory? Chance cannot. It can go only a little way. It can take but single steps. It is the easiest thing in the world in most cases to distinguish between the fruits of the operation of chance and those of the operation of mind. Blind forces cannot. No unintelligent ground or principle of existence can. No nonentity can. No entity that is not intelligent can produce, on an extended scale and with consummate perfection, really clear and brilliant signs of mind. Where the signs are indistinct, where there are only the faintest shadows, the most distant resemblances to the work of intelligence, it may be impossible to determine whether intelligence has been present and has acted; but where the signs are of dazzling clearness, where the marks are multitudinous and the footprints of matchless form, there cannot, there assuredly ought not to be, the least hesitation in coming to a conclusion. If a small portion of any kind of food tasted slightly of salt, one might not be sure that it had been

salted; but if the whole tasted of it, tasted strongly of it, there could be no doubt. The whole world in all its atoms, molecules, and entities of every kind, is salted with mind. He that studies the sciences tastes of it at every point, tastes it in its strength; it stirs his admiration and kindles his enthusiasm; his intellect glories in the law and order which prevail. No sane man doubts that the sea is salted with salt, doubts that it is salt with which it is salted. The evidence is as overwhelming and irresistible that the earth, and matter in its every atom, and every entity known, is salted with mind, has on it the clearest marks that it is the work of mind.

II

ATOMS AND MOLECULES

Atoms—Number of Divisions—Numbers—Weight—Size—Forms—Molecules—Motions in Gases—Effects of Heat—Of Pressure—Diffusion—Law of Numbers.

I. *Atoms—The number of kinds.*—The number known is constantly changing. It is now increasing, now diminishing. It has happened that a supposed element has been broken up, and been proved to be not simple but compound. New elements are also being discovered, as in the case of argon. The number has been set down at various figures not much under seventy. Is not this a most impressive fact? Is it not a condition of matter full of meaning? Considering the amount of it in the universe and the number of particles at every point, is it not an exceeding marvellous phenomenon that they are all so ordered as to fall easily and perfectly into line under about seventy divisions? There are not seventy thousand, not seventy million, not seventy billion, but seventy. Had they been vast in number, they would have made a medley so multifarious as to be unworkable, they would have rendered an ordered and compact system of things an impossibility. It is not easy to reduce ordered but mixed multitudes to their natural order. It demands perception and attention, thought and care. A housewife, with a large amount of goods and many considerations of taste to determine, is ready to be almost

distracted arranging them in a new home. If there were few things of two or three kinds, the task would be easy. Thirty thousand volumes would tax for no short period a born librarian to arrange in the best order. It has taken weeks, and sometimes months, of painstaking care and experimental testing to determine single numbers, a 12, a 14, a 16, representing atomic weights. Investigators, caring only for truth, have counted no amount of careful research and persistent labour too great to win the prize of a single definite and accurate result. But in such cases the order existed, and needed only to be brought into view. To bring the order into existence, *hoc opus, hic labor*, this is the work, this is the labour. To make the goods, to produce the volumes, needed thought and labour greater far than to arrange them. And surely to deal with every particle of matter in the universe, so as to make it of a special type, to order all, so that they might come under types so few and compact, demanded an amount of thought and work of overwhelming greatness, and could not be the result of chance.

It is not a small thing also that the number should be so suitable for the finite minds of earth, enabling them to build up a science of them. To bring all matter under command so perfect, into a state of fitness for work so magnificent, into a condition so suitable for spreading out before the intelligences which have appeared in the world most interesting fields of knowledge, was assuredly of a mind which knew the end from the beginning.

This point is strengthened in that the elements are still further divisible into classes: into two, as metals and non-metals; into three, as gases, liquids, and solids. The power of classifying and naming belongs to mind only. Much more does the power of producing the possibilities of classification belong to it. By far the larger number

of elements are metals. They number over fifty. The particles belonging to them can all be put into one class, and called by one name. They have the same nature, the same metallic lustre. Gases, liquids, and solids have their respective temperatures and pressures, at which they are gases, liquids, and solids.

The number of atoms existing.—A cubic inch of a perfect gas, when the barometer marks 30 and the thermometer stands at 32°, contains 10^{23} molecules, *i.e.* a hundred thousand million billion, and in certain cases that means two or three or four or more times as many atoms. A cubic inch of water gives 1800 cubic inches of steam, *i.e.* water in the gaseous form, and, therefore, to obtain the number of molecules in every cubic inch of water, we must multiply 10^{23} by 1800, and as there are two atoms of hydrogen and one of oxygen in the molecule of steam, we must multiply that product by three. We thus reach the conclusion that there are hundreds of billions of billions in a cubic inch of water. In the feeblest spring and tiniest well, in the Don's fountainhead, where, with a small vessel, you may quench your thirst, how many are there? In the springs and rills and streams that feed it, how many? In all earth's rivers, lakes, seas, and oceans the numbers are overwhelmingly vast. The smallest amount of matter that can be seen by the microscope contains from 60 to 100 million molecules. In our persons, in our houses, in a great city, in a molehill, in a round mound, in a ridge of mountains, the multitudes go far beyond numbers that can be named. To set down the numbers in the earth would need not a page but a field of paper. But the telescope has made known to us that the sun, moon, and stars, which to the naked eye seem so small, are mighty globes, and some of them so large that the

earth is insignificant in comparison. And though by the naked eye only two or three thousand stars can be seen, the telescope reveals in the Milky Way many millions. And these are suns, and have doubtless planets attending them. These millions belong to one nebula, and nebulæ are in thousands, and consist either of suns and systems or of matter being gathered into suns and systems. And the spectroscope tells us that the same substances to a large extent are burning in them as in our own globe. And beyond the spaces swept by our telescope there may be immeasurably vaster numbers of suns and systems than within them, so that to the imagination winging its way through immensity, the poet might justly say and sing—

"Before thy path Infinity!
Fold thy wings drooping, O thought eagle swooping;
O phantasy, anchor, thy voyage is o'er;
Creation, wild sailor, rolls on to no shore."

And all the matter that is, we repeat, is ordered and crammed with thought from its circumference to its core, from its giant orbs to its minutest points, from its most complex organisations to its minutest atoms. And on every atom the finger of mind has printed itself. He counts the number of the stars; to His understanding there is no number. He counts not the stars only but the atoms, the atoms one by one, the atoms every one—those in a cubic inch of gas, of water, those in all waters, those in a molehill, in the whole earth, in the sun, and within range of His influence, in every sun in the heavens, in all nebulæ, in all space. Their numbers He knows to a unit. His thoughts and painstaking care and matchless hand are on every one.

Their weight. — The weight of substances is of first importance in chemistry. The greatest accuracy in

weighing is necessary. A chemical balance is therefore an instrument of exquisite delicacy. It is suspended, when in use, on a fine knife edge of agate, and removed from it on every occasion when it has served its purpose, to prevent wear and tear. Its arms are measured with greatest care, to ensure their perfect equality in substance and in length. By these means friction is reduced to a minimum, and its sensibility to the least addition or withdrawal intensified to a maximum. It is capable of determining weight to the one-millionth of the substance weighed.

Indirectly, and in different ways, on rational principles, atoms can be weighed. The weights of sun, moon, and stars can be scientifically determined, and so it is possible to weigh also the smallest particles. It is easy to weigh ounces, pounds, hundredweights, tons. It is not so easy to weigh atoms. But the results are as real, as definite, as certain. The weights are of course comparative. There must be a standard of comparison, and hydrogen, as being the lightest of substances, is adopted. Hydrogen is 1, carbon 12, nitrogen 14, oxygen 16, magnesium 23·94, aluminium 27·3, phosphorus 30, chlorine 35·5, iron 55·9, zinc 66·9, silver 107, gold 196·2, mercury 199·8, and others between these weights, and above 200. Weigh an equal number of atoms of these elements, and the weights are always according to these proportions. A number of carbon atoms are always twelve times heavier than the same number of hydrogen. Atoms of the same kind are thus practically of the same weight. They are attracted in the same measure by other atoms and aggregates of atoms. There is not a billionth of difference between them. Every atom of hydrogen weighs alike. Every atom is fitted to be a standard measure of weight. Every atom of carbon throughout the vast realm of the

existence of that substance is borne towards attracting masses by the same measure of force. Every atom of nitrogen or oxygen in the atmosphere encompassing the whole earth is drawn towards its centre to the same extent. Atoms of sodium, if on the earth or in the sun, in Sirius or distant Orion, or wherever in the universe they exist, are true, each one to its kind, attract and are attracted even as they. It is so with every element.

It is, we say, indirectly that atoms can be weighed. It is far from the power of man to separate atom from atom, weigh the one against the other, and note the perfection of their balance. It is far beyond his power to devise and make a balance for an experiment so fine. He cannot deal with single atoms. He lacks, even when aided by the microscope, the perceptive power and the refinement of touch capable of distinguishing, handling, or in any way singling them out and acting on them. And yet single atoms have been in some way dealt with, handled, and acted on. Every particle has been weighed, and weighed to a nicety, is of a weight that corresponds with minutest exactness, with that of the countless particles of its kind. Never was balancing like it. The greatly differing weights in the different kinds of atoms so small, render more impressive the sameness in the same element. What, then, hath weighed them with such accuracy? Where were the balances found? What possessed the power of using them in such a fashion? What made all the atoms of hydrogen of one lightness? What made those of oxygen sixteen times heavier, those of all the elements just their own numbers of times heavier? Let a man produce before a company huge scales of accuracy so exquisite that a grain of dust would disturb the balance; let him put into the one a mighty mass of iron, into the other of copper; let him vary the

substances, and consequently the size of the masses; let him show a large number to choose from, and in every case let there be a perfect level and stillness of the scales; let there be accuracy such that the least dust would be seen to disturb the balance—would not every witness be filled with admiration, and ask in wonder how such accuracy could be attained, and be sure that much thought, and planning, and closest attention, and care had gone before? Would not every witness regard with scorn the suggestion that all was the result of chance? And when we consider the elements of the universe, their infinitesimal smallness and the nicety of the weighing with which they are weighed, what ought to be the boundlessness of our wonder, the fire of our admiration; how ought we to yield our whole being to the conviction that a seeing and understanding nature hath done this, that a hand of inconceivable power and fineness of touch, associated with matchless intelligence, hath accomplished it!

The size.—Four lines of experiment and of argument lead to the same conclusion as to their size. They are from $\frac{1}{10}$ millionth to $\frac{1}{100}$ millionth of a centimetre in diameter. Lord Kelvin imagines a globe of water about six inches in diameter, magnified to the size of the earth, and each molecule magnified in the same proportion. The molecules would in this case be larger than in a heap of small shot, but probably smaller than in one of footballs of about six inches in diameter.

The atoms of the same substances are practically of the same size. There is the same amount of matter in them. They occupy space. They are extended. They are small, but of the same smallness. They are minute, but the exactness of their correspondence in minuteness is still more minute. Every atom of hydrogen fills the same

space. Every atom of oxygen occupies the same sized point. The atoms of carbon, nitrogen, and all other substances do the same. All the elements might be represented by lines of indefinite length, and the same lines formed of points of the same size. Here are measurings the most amazing. Here is the finest determination of sizes on a scale of immeasurable greatness, in multitudes without number. What, then, determined those sizes? What measured them with an exactness so minute? What produced a correspondence so amazing? How can we account for all matter being in its elements so ordered in magnitude as to be like, say, seventy lines of points so fine as to be invisible, and all those in the same line of the same size? Where could the pen be found to produce such representing points? where the hand of perception so keen, the hand of touch so fine, as to form them? What could do such work but mind, a wondrous mind associated with perceptive power the keenest, and a hand and finger of transcendent fineness of touch?

Their shape.—Lord Kelvin has propounded a theory of vortex ring atoms. They are in the shape of rings, and have vortex motions. They form the parts of a perfect fluid which fills space continuously and is absolutely mobile. The fluid is a perfect fluid, and friction is wholly absent. They must be of some perfect form in order to be suitable for chemical combination. What, then, shaped them so suitably? What can mould and fashion? What can form into regular figures? What but mind and mind alone?

II. *Molecules.*—A molecule is not the same as an atom. The latest chemistry carefully distinguishes them. Atoms are the smallest particles that can be obtained by any means chemical or physical. Molecules are the smallest

that can be obtained by physical. The atoms and molecules of the elements are for the most part different. In mercury and iodine at a certain temperature the molecule and atom are the same; the molecule, *i.e.*, consists of one atom. But in a volume of oxygen gas, of hydrogen, nitrogen, chlorine, a molecule consists of two atoms. The atoms of these substances refuse to remain single. It is not good for them to be alone, and rock to and fro in solitary activity. When they can find no other atom to which to attach themselves, when all around are atoms of their own likeness and family, they fasten on and link themselves to each other. In a jar, therefore, of these gases, the separate and independent molecules are each composed of two atoms. Ozone is a cluster of three atoms of oxygen. Phosphorus clusters in four, arsenic in four, sulphur from 450° to 550° in sixes. The atoms of mercury and of iodine at a certain temperature mate not with each other, and in this all are alike. The atoms of hydrogen mate in twos, wherever hydrogen is found, and are followed in this by nitrogen and chlorine. Oxygen rejoices in twos, and becomes exhilarating in threes, and it is always so with it. All phosphorus atoms are so constituted as to seek association with each other in fours. Sulphur is hard to satisfy with company, and its every atom shows the same covetous or affectionate nature. How perfectly the atoms of substances are made alike in this respect—for made we cannot help concluding that they are!

Motions of molecules.—In a volume of gas what are the molecules doing? Is each resting in its place? When a jar is filled with them, when they have had time to settle after being conveyed into it, do they become still and rest in one position? No, they continue in motion. Every molecule in the jar is moving to and fro without

ceasing. They encounter the side of the jar in the vastness of their number, and are continually beating and pressing on it. They encounter each other, and billions of collisions are taking place every instant; billions of blows are being given and received. Everyone gives as good as it gets, and gets as good as it gives, though all is of the feeblest, and no clash of battle is heard. Great is the commotion among them. Great is their activity and multiplied their motions. They are not always moving every one with the same velocity. The mean or average velocity is, however, always the same in the same gas. It is different in different gases. The measure of difference is determined by the density—the greater the density, the less is the velocity; the less the density, the greater is the velocity. It is, however, to the square root of the density that it is inversely proportional. The mean velocity of hydrogen molecules, when the temperature is at the freezing point and the barometer showing a pressure of 30 inches, is 6097 feet per second. Every molecule in a jar, therefore, is running to and fro with great rapidity, and covering a distance of 1 mile 272 yards in a second. The density of oxygen is sixteen times that of hydrogen. The square root of 16 is 4, and the velocity of oxygen molecules is one-fourth that of hydrogen, or 1524 feet per second. The density of chlorine is 35·5, say 36, and the square root is 6, and therefore the velocity 1016 feet. In a jar of hydrogen every molecule is travelling $69\cdot\dot{2}\dot{7}$ miles per minute. In a cubic inch the distance accomplished by all is $69\cdot\dot{2}\dot{7} \times 10^{23}$, and if myriads of jars were tested, and the number of miles calculated, that would practically be the proportional number. In oxygen and chlorine jars the number of miles covered by a molecule would be 17·32 and 11·54 respectively, and for those in a cubic

inch, these figures multiplied by 10^{23}. Wherever jars of these substances can be obtained, wherever they exist, each in like circumstances execute their motions with like rapidity, making the same number of miles per second, per minute, per day, per year, to the praise of the hand that made those of the same kiud so perfectly alike, that meted out to them their properties in measure so exact.

All gases are acted on by heat in the same measure. The average velocity is increased by it. The higher the temperature, the greater the velocity; the lower the temperature, the less the velocity. Could a gas be cooled down to $-273{\cdot}72°$ C. or $-462{\cdot}696°$ F., its molecules would be reduced to stillness. There would be in them no motion, no energy, no heat. The volume is also increased by heat. The measure of enlargement has been determined. By every degree of increase of heat a gas expands by $\frac{1}{273}$rd of its volume; or 273 cubic inches under an increment of 1° C. becomes 274, of 10° 283, of 27° 300. An increase of 273° doubles the volume. Let the same volume of hydrogen, oxygen, and chlorine, and any number of gases, be subjected to the same increase of temperature, to an increase of ten, twenty, fifty, or a hundred degrees, all will keep the same pace in enlarging. Each will increase, step by step, according to the heat increment, and each step will exactly correspond, and the volumes throughout will be of the same measure. The measure is finer far than any to which man is equal. The steps are more accurate than the tread of armies. Every particle of all the gases knows the increased room to demand, and, however little it may be, demands it. They are in trillions, in septillions, or it may be in centillions; but so perfectly constituted are they, so entirely are they

under law, that they ask not an infinitesimal part of a hair's-breadth more, and will not take an infinitesimal part of a hair's-breadth less, and so the measure of increase, which their mighty numbers claim, varies not.

The volume of gases is acted on in the same measure by pressure. It is inversely proportional to the pressure to which they are subjected. Increase the pressure to double the amount, and the volume is reduced to one-half; to fourfold the amount, and the volume becomes a fourth. Reduce the pressure from four pounds to two, and the volume is doubled; to one, and it is enlarged fourfold.

The expansion and contraction of gases, according to the measures of heat or pressure brought to bear upon them, are thus the same for all substances in the gaseous form. They all act in the same manner. They have their motions and forces and condition ordered, measured, and balanced so as to obey the same laws. There are none inert, disobedient, or rebellious among them. They are all active, all in perpetual motion, all exerting and yielding to force, and alike related to the physical forces which can be brought to bear on them to determine their relative positions, all responding to their action with the same readiness.

Diffusion of gases.—The diffusive power of gases is of vital importance. When they do not enter into combination by contact, they pass through each other, and become a mixture. However much they differ in specific gravity, and though the heaviest be lowest, it will ascend, and the lightest will descend. Fill a jar with hydrogen, and if the temperature and pressure continue the same, there cannot be put into it more than the right and definite number of molecules. The same number of oxygen molecules may, however, be added, and also of other

gases. By certain arrangements such a quantity of water may be poured into a glass globe as, when raised to the boiling point and wholly evaporated, will fill the globe. Pour in more water, and not another molecule will at the same temperature and pressure be added. But if ether be substituted, the same number of molecules will rise among the steam. A third and a fourth vapour may be added, and each will be of the same number. The molecules of steam thus prevent any more of their own kind from rising among them from the water than according to temperature and pressure, but they welcome those of ether, or of any other kind. The ether molecules also determine their own number, but they do not stand in the way of other kinds.

Each gas has its own measure of diffusive force. It is inversely proportional to the square root of its density. A bottle of hydrogen, open to the air, will lose 94·5 per cent. of this gas in the same time as that in which a bottle of carbon dioxide will lose 47 per cent. In different gases the diffusive power is different, but in the same gas it is the same.

The law is in many respects a very wonderful one. Non-interference of a gas with other kinds of molecules, while resisting the rising or descending among them of additions of their own kind, is a very remarkable arrangement. Were it otherwise, life could not be continued. Deleterious gases would collect. Carbon dioxide breathed out by all animals, were it not diffused through the air, would fill rooms and all kinds of enclosures and places where animals congregate, and would be the ending of their life.

Avogadro's law.—Equal volumes of all substances, in the state of a perfect gas, and under like conditions, contain the same number of molecules. A jar of oxygen

contains, suppose, 30 cubic inches of gas. In each cubic inch are 10^{23} molecules, and therefore altogether 30×10^{23}. A jar of hydrogen of the same size, and under the same conditions, will also contain 30×10^{23}. One of nitrogen, chlorine, or any gas, will have the same number; or the same jar will contain just the same number of each. It is the same number of molecules, not of atoms. The number of the latter differs in the molecules, and therefore also in the jar. What determines the number? There are the action of the molecules on each other, the same heat energies and pressure of the atmosphere. And though the molecules involved be so great in number, the heat motions so multitudinous, and the atmospheric pressure produced by so lofty an atmosphere, so perfect are their constitution and action that they everywhere and always, in the case of every gas, put the same number of molecules into the same space. Were the space increased to cubic yards or miles, they would still be equal to the task. So perfect is the constitution of molecules, and the action of all natural laws on them, that they can put enormous numbers into the same spaces, and always the same. If a shepherd had ten thousand sheep, and wanted to put them in hundreds into pens, each one having a measured space around it, in which it might move freely, as have the molecules, he could not accomplish such a task without careful counting and measuring. And nature could not accomplish it without the vastest amount of measuring going before. And so, although it may be said that it is natural to gases to obey these laws, we cannot but ask, Why is it natural? The simplest and most natural results that are, have great meanings. They speak of order. They could not be produced without it, without a great amount of it, and of the finest kind. There cannot be a single law without

measurings and sameness the most minute. There cannot be gases contracting and expanding in the same measure without all being in their essence constituted on the same principle. The results could not be produced were the volumes each a chaos.

III

CHEMICAL COMBINATION

Affinity—Its Adjustments for Action Exquisite—Universal—Uniform—Manifold—Varying in Measures—Persistent—Stable—Argument Independent of the Atomic Theory.

WE now come to consider the case of atoms in chemical combination. This is one of the most interesting of the fields of science. It is crammed with wonders. It is crowded with adjustments. It is packed with adaptations. It is pervaded by order. Throughout its length and breadth the presence and action of mind are revealed. Mind is everywhere in it, shining in ten thousand nice adjustments, ten thousand thousand exquisite adaptations.

Chemical combination is to be distinguished from mixture. Nitrogen and oxygen form a mixture in the atmosphere. Hydrogen and oxygen may also be made to mingle without entering into their most intimate union. In chemical combination the atoms are not only mixed, and in such a manner as to show only the qualities of a mixture; under the influence of a peculiar force they approach each other in a union so close as to create a new substance, differing entirely in nature and qualities from its constituents. A chemist familiar with every property of the simple substances, able by his tests to detect them in the smallest quantity, if a new substance were presented to him for examination, would not be able to form a correct anticipation as to the elements which, by their

combination, constituted it. Chlorine, a yellow gas of suffocating properties, and sodium, a metal of white colour, combine to give us common salt. Who would imagine beforehand that water is composed of two light gases. In every case of real and perfect combination the qualities of the constituents are lost, and seem to be even destroyed, so entirely have they disappeared. Even when the same elements combine in different proportions, the resultant compounds are as unlike as any others, and are separated by a wide gulf.

The laws of chemical combination suggested to Dalton the atomic theory of the constitution of matter, which he propounded a century ago. He deduced it from the laws of definite and multiple proportion. He found that when one element enters into combination with another, it is always in the ratio of 1 to 1, or 1 to 2, 1 to 3, 1 to 4, or 2 to 3, to 5, to 7, etc. From this he concluded that the elements consist of atoms which unite in definite and fixed numbers to form compound molecules. This theory has held the field for a century, and still holds it. Modifications may await it in the future, but, as we shall see, they can only be in the direction of order, and therefore not of a nature affecting our argument.

In chemical combination, when two or more different kinds of atoms are brought together in appropriate circumstances, they close together, they form a new molecule, revealing new qualities. And in the same circumstances, the myriads of the atoms of the one combine with the myriads of the atoms of the other. Between the two kinds of atoms there exists a chemical attraction or affinity which produces the results. For illustration, a few examples may be presented. Hydrogen and oxygen are gases consisting of atoms: mix them together and introduce a burning taper; an explosion takes place, and

water is formed. Two atoms of hydrogen have rushed into union with one of oxygen, to yield a molecule of water. The formula H_2O is used to indicate this. In hydrochloric acid (HCl) one atom of hydrogen combines with one of chlorine, in ammonia (NH_3) three atoms of hydrogen unite with one of nitrogen.

The compounds of the same elements in different proportions, as in N_2O, NO, N_2O_3, N_2O, N_2O_5, are substances of entirely different properties.

When, then, an atom is examined, it is found to be infinitesimally small, to be weighed, measured, and shaped with inconceivable nicety. As far as it was concerned, it might have stood alone in immensity. There might not have been another existing; but, lo! another atom, infinitesimally small also, and similar to it. Even these two exquisitely cut gems, if we could perceive them, would compel us to say, Here are clear marks of mind. It is evident that the hand of intelligence has given to these atoms their characteristics, and made them alike. But when we find that there are not only two or three alike, not only millions or centillions, but numbers for which there is no name, the certainty that their likeness is due to mind becomes overwhelming. But we find also another kind of atom, different in every respect, and multitudes like it, multitudes beyond all numbers, and these in like manner proclaiming that their wondrous order is due to a skilful hand; and when two of these atoms are brought together in appropriate circumstances, they draw close to each other, they form a new molecule, revealing new qualities. And in the same circumstances, the myriads of the atoms of the one combine with the myriads of the atoms of the other. But there are not merely two, but nearly seventy kinds; and all the atoms of each and every kind are characterised by the force of

affinity; and if we consider its action throughout the whole field of matter, we shall see that the evidence of the presence and action of mind in it is overwhelmingly strong.

Chemical affinity shows an adjustment of the finest kind, of nicety unapproachable. What the exact form and nature of the atoms may be, in what way they unite so intimately as not to be like a mixture, but to manifest characteristics entirely new, it may be impossible accurately and certainly to determine. But it is as impossible to entertain the faintest doubt that they have a form and nature very specially suited to their entering into the glory of chemical union. Not every chance form and nature would permit; irregularity even of figure would prevent; even the figure must be exquisitely adapted. And of still more exquisite perfection of adaptation must be the force that unites, must be the characteristics which mingle so matchlessly. The force must be minutely adjusted, the qualities minutely adjusted. The least deviation from exact correspondence in either would render their combination impossible or irregular. But throughout the whole chemical field no irregularity is found. Is it not then a mark of mind, most clear and finely impressed, that atoms have a form and nature which fits them for an adjustment the finest, an adjustment immeasurably finer than any devised by the genius of man?

Chemical affinity is a wonderful adjustment and characteristic of matter. Simple mixture, though widely useful, is nothing to it. How beautifully the atoms act! How splendidly they do their work! What cunning virtues they manifest! What activities they show! What readiness for the exercise of their powers! How perfect is their adaptation to what seems to the

reasonable mind to be their purpose! How exactly, and with what accuracy, they spring into their place, into the many places they fill! How gloriously perfect are their unions! How marvellous is the complete obliteration of their old properties and the distinct presentation of the new! The old disappear without leaving a vestige; the new appear, pure, and untrammelled by anything that belonged to the old. A great painter being asked with what he mixed his colours, answered, "With brains, sir." It was with hand guided by perceiving intelligence; it was a genius for colours that enabled him to produce effects that were the admiration of beholders. With what have the elements of matter been mixed after a chemical manner—after a manner with which no mixing of colours can vie? With mind; with mind, that glows in their action above the brightness of the sun; with mind, that formed, that adapted, that charged them with measured chemical force.

It is a universal characteristic of matter. Every atom is distinguished by it. There is not a substance known that is not constituted after a chemical manner, that has not a relationship to some other, that does not enter into combination with some other to form a new compound. Even in the case of those that are rarest, the force of affinity is so strong that there is the greatest difficulty in separating them for examination. This amazing property of matter, this finest of adjustments, that would have filled us with admiration if it had existed on a small scale in a little corner of nature, is in every corner, and fills the universe. Every atom declares that it exists not for itself alone, but for its neighbour, that the essentials of its condition stand carefully adjusted for the most beautiful and wonderful and perfect of unions. Every atom in the vast field of matter is a gem carefully cut, is

a work of consummate art, is in its nature and qualities an ideal of adaptation, and proclaims with all the force of everything that is in it and about it, that it owes its existence to a hand of matchless wisdom. A few atoms would speak with power, a jar of them with irresistible force. But there are worlds of them. There are worlds on worlds. And all speak loudly and clearly. Nowhere is an uncertain sound heard. Not an atom hesitates in its testimony, but ringing clear, as from golden mouth, as with perfect articulation, and truth's own vigour, ascribes the glory of its condition to an understanding mind.

The action of the atoms is uniform. They might have differed in the temperature or circumstances of their entering into union. But all the atoms of the same element are so perfectly alike, have the measures and characteristics of their force determined with an exactness so exquisite, that their septillions and centillions act at the same moment in the same circumstances. They are as septillions of strings composed of the same substance, made of the same thickness, cut to the same length, drawn to the same tension, tuned to the same note. They are as centillions of jars charged with the same electrical force. All in contact with the same element are thrown into activity at the same instant, at the same point. They know it everyone; they recognise it. Its touch is magic. As with one accord, and perfect intelligence, they spring into the right place, leap into union in the right manner and number. They need no hand of operator to guide, or set right the position of any one of them. Within the same range of circumstances, too, they continue in union, they cleave to each other, they hide themselves individually, and show only their combination qualities. And again at the same point or points, they relax their grasp, start aside and become themselves

again. In short, in every possible variety of conditions the affinities of the same elements are found to be in the same line, to move at the same moment, to continue union within the same range. How impressive is this uniform action! How marvellous is it that the force should in every atom of the two or more elements entering into combination, be so exactly measured, as that multitudes so vast should be moved with the same simultaneousness, that in every case the conditions of action stand exactly at the same point, and that they combine one and all to show the same perfection of likeness in the compound molecules. Whence then agreement in action so perfect? To what can we ascribe uniformity so universal and extensive? Not surely to the multitudes of atoms themselves; not to any thing or any ground of being in them; no, not to multitudes, but to one, to one mind, to one conscious mind capable of producing agreement so wonderful, of creating uniformity so matchless.

The atoms of each element have many chemical affinities. Oxygen combines with almost all the others, though there are some for which its affinity is weak. Hydrogen enters into a great many unions. Carbon forms a multitude of compounds which are of first importance in the economy of nature. Chlorine combines with all substances. Bromine unites with most metals at ordinary temperatures. Iodine and fluorine have similar affinities. Oxygen, in its nature, form, and force, is thus adjusted with this exquisitely nice adjustment to more than sixty different kinds of atoms, differing in nature, form, and force from it and from each other. It might have been adjusted to one and no second. Every additional adjustment is an added contingency. It is as if it had been made, and in the making of it all the atoms of all the elements were kept in view; and as if they had

been made, and in the making of them oxygen had been taken into account. The same is true of chlorine. It is as if in the making of it, union with the other elements was provided for, and in the making of them they were prepared for union with it. It is as if in the making of each and every element others were considered. The interaction among them is exceedingly extensive and complicated. The number of affinities is very great; it is enormous. With manifold force, therefore, does every individual atom of all the elements speak of itself as formed by mind.

The intensity of the force differs between different elements. A substance may have an attraction for two others, but stronger for the one than for the other. That of chlorine for oxygen is very feeble, but for hydrogen it is very strong. Chlorine, iodine, bromine, fluorine combine readily with metals, but the energy of the action is in the order in which we have presented them. Sodium, potassium, and three other metals have an exceedingly powerful attraction for oxygen. So violent is it that when a piece of them about the size of a pea is placed on water, it bursts into flame. The metal, by simple contact with the water, detaches the oxygen from the hydrogen, and draws it with rapid and irresistible vigour into union with itself. Sulphuric acid has an attraction for magnesia and also for soda, but stronger for the latter than for the former. The intensity of the force in each element and compound is suited to the place they fill and the purposes they serve. The attractions between element and element, between element and compound, between compound and compound, are set in an order that cannot be improved, that commands an enthusiasm of admiration. It is owing to this order that the operations in the laboratory of the chemist and the chemical

manufactory can be carried on, that the myriad operations and chemical changes in every department of nature are in constant activity. The riches and complexities of arrangement shown in this order proclaim themselves with overwhelming power as due to mind.

Chemical affinity is a persistent force. The atoms never lose it, nor the qualities which it brings into play. No changes, however multitudinous, exhaust or diminish it. Atoms unite with atoms, and in union seem to lose their identity, seem to forget themselves and all that they were. They merge themselves in each other. There is not the slightest sign of the individual element. And thus united they might have communicated their properties to each other irremovably. Seeing they mingle them so perfectly, it might have been that in combination they would lose them to each other, and so there would have arisen inextricable confusion. But when a combination is broken up, each element carries with it everything belonging to itself and its kind, and nothing more. No atom gives out of itself an infinitesimal portion of what is properly its own. On whatever its characteristics may depend, it suffers no measure of any of them to be separated from it. It retains for ever unaffected in any way its every affinity. This is a contingency found in each atom, found in all the atoms.

The compounds have various measures of stability. In some it is weak; in others it is strong. In the former the range of conditions in which the union begins and continues is narrow. In the latter it is exceedingly wide. Phosphine PH_3 prepared in one way and introduced into air or oxygen at once takes fire. Chlorine peroxide ClO_2 at a temperature below the boiling point of water explodes with great violence. There are compounds which the least elevation of temperature,

which the lightest blow, which a touch, can break up. The great majority of substances have, however, a firm stability. Amid countless possibilities, amid contingencies without number, the condition in which their constituents unite are easily available, and the range of conditions in which they continue united is comparatively wide, so that they have the stability required for the purposes they serve in the ordered world. At the same time their stability is not too great. This would prevent their being useful as effectively as if it were too feeble. The stabilities are measured. They are adjusted to the place and uses of each substance.

Matter then, in its very elements, is a field of the most beautiful order. The atoms of each element are the same in all their characteristics and measures. If it be affirmed that matter is eternal, and therefore that it is not an effect and does not require a cause, yet are we entitled to demand an account of the samenesses, and likenesses, and differences, and relationships that reign throughout its borders. They cannot be ascribed to the atoms themselves. Nothing can act before it exists. If atoms be supposed to be self-existent, they yet could not set their nature in order. They did not take counsel together as to what their various properties and measures of properties should be. No atom understood itself, much less its fellows, and therefore could not set itself in order, or adjust itself to them. They cannot be ascribed to necessity. There can be no eternal necessity, there can be no eternal reason of any kind, why there should be sixty or seventy or any definite number of elements, and why such multitudes of the same element should in so wonderful a manner be distinguished by the same qualities and potencies in common. They cannot be ascribed to chance. They are so extensive and wonder-

ful that it is as impossible for such an account of them to cling to a sane mind, and sting it with doubt, as for a wasp to live in the hottest flames of the sun. They can only be ascribed to mind. Every atom has on it not one but many marks of being artificially made, is a gem flashing in every facet with the light of intelligence.

The size of the atoms is of course relative. Let us magnify them to a clearly visible size and represent their qualities by visible characteristics. Let the atoms be likened to cubes and let the sides, coloured differently, represent the various qualities. If then you were to come upon a few such similar cubes, there would be no hesitation in concluding that they had been made by an intelligent hand. But if, side by side with them, you met with others differing in size and shape and colours from those of your first discovery, but exactly resembling each other, you would feel that your conviction was, if possible, strengthened. But if you found not two nor three, but fifty, sixty, or seventy, cluster differing from cluster, but all the atoms of each cluster the same, you could not but feel the evidence for their being manufactured overwhelming. And this is what we find in the universe. In it we have seventy different clusters of enormous size. How vast a space would all the atoms of oxygen in the worlds within view of man's aided eye occupy! Hydrogen and nitrogen and carbon would each form a globe of immense magnitude. Each and every element would also do so. If the eye could be aided to see them clearly, and to perceive their form and various properties, the mind could not resist the conviction that they are made.

Stones and wood disposed so as to form a graceful, convenient, and comfortable building, show the mind and hand of an architect and builder. But the stones them-

selves may as distinctly indicate that they too have come from the same quarry, and that they have been shaped, measured, and fitted for their place by the same or like cunning hands. And the wood may make as clearly manifest that it has been taken from the same kind of trees, and also cut and planed for its place. And so the worlds make manifest that they have been formed by an Architect and Builder of transcendent wisdom and power. And when we examine the material employed to form so many structures, we find that they speak in unmistakable tones of the skilful hand from which they have come, of the designing mind which made them for their place. They are as if for a building you were to find everything fully prepared, the stones of requisite size and shape, and ready to be placed on each other so that no seam could be seen; the wood also ready for the nail and hammer, and even nail and hammer and all things necessary for the raising up of a commodious structure. "Master, see what stones and buildings are here!" The buildings were extensive and noble. The stones were huge, and created astonishment and admiration. But see infinitely greater wonders. See the stones and buildings of the universe. Behold the earth; lift up the eyes to the heavens. What buildings are here! How noble are these structures! These are the buildings to be admired. These are the structures to fill an enlarged imagination with a sense of grandeur and magnificence for the ages of ages. See what stones! What stones for such structures! They are not huge blocks. The wonder of them does not lie in that direction. It lies in their smallness, in the extreme minuteness of their size. But see them! Every stone is a study. Every atom is a marvel. Every cluster is an array of astounding marvels. Every stone is measured, weighed, and shaped and ready for building, ready to

build itself, having a readiness to be seen nowhere besides. These we say are the stones to be wondered at. These form a sight to kindle the soul and make it burn with everlasting admiration. Admiration of what?—of the fruits of chance? No; of the fruits of mind, of its glorious and inspiring triumphs.

Matter is thus, through and through, to its least atom, and in its lightest characteristic, pervaded by order exquisitely perfect. But it may be said that the atomic theory is only a theory. It holds the field. Amid the advances of a century it works well and fruitfully. But it may be modified. But it cannot be modified save in the direction of order. Our argument does not depend on any mere theory. It depends on phenomena actually observed, on facts placed among the certainties of science. It depends on the measured qualities and forces, on the order and adjustment which are undeniably characteristic of matter in its elements. The atomic theory may be modified in some respects, but it cannot be so modified as to exclude the wealth of order revealed in the laws of chemical action and combination. The new or modified theory must include these, and reveal some more wonderful explanation of them than that now given, or reveal some special point at which new light as to the mode of action breaks forth. But the new will only show more perfect action than the old, will only be a more perfect representation of the mode in which the work is done. In short, no variation in theory can touch even with the lightest finger the contention that matter from its circumference to its core, from its most complex combinations to its simplest elements, is pervaded by the most perfect order, is therefore crammed with signs of mind and is its work.

IV

LIGHT—THE ETHER IN ITSELF

The Ether—A Medium differing from Ordinary Matter—Nature of Wave Motions—Action in the Ether itself—Its Motions Advance in Straight Lines—Velocity of Light, Great, Suitable, combining Maximum of Forward Velocity with Minimum of Forward Force—Waves—Transverse Vibrations.

The field of chemical science is crammed with beautiful order and action. In it the elements of matter are seen to possess characteristics so exactly measured, to show adjustments to each other so exquisitely determined, to present signs of mind so many and so brilliantly clear, as to inspire the rapture of admiration, and lead with irresistible force to the conviction that they have been made by a mighty intelligence.

In light and the science of optics, we meet with the same wealth and complexity of order, with the same, if not greater, beauty and exquisiteness of action, with the finest adjustments of a new and widely different element to ordinary matter,—we meet with signs of mind transcending in brightness the shining of light itself.

More than two centuries ago, a Danish astronomer, Olaus Römer, made the important and fruitful discovery that light travels in time. It does not come from the sun to the earth by instantaneous transmission. Its velocity is finite, and can be measured; and by his calculation, 192,000 miles per second. Modern observers

and experimenters have measured it in a direct manner, and fixed it at 186,000 miles.

Two theories have been advanced as to the manner in which light is propagated. The first, the emission theory of Newton, represented its rays as made up of infinitesimally small particles emitted by shining bodies; these sped forward as arrows from a bow, stones from a sling, bullets from a rifle. The sun would on this theory be continuously sending forth from his body innumerable bright particles, which, reaching and entering the eye, produce the sensation of light. This view, though long maintained, has been discredited. Observed facts contradict it. The second is called the undulatory or wave theory. It regards light as flowing from the sun to the earth by means of a medium thrown into a state of wave agitation. These waves spread through the medium in all directions, after the manner of those caused by a stone flung into the water.

It has been found necessary to assume the existence of a medium different from ordinary ponderable matter, to which the name of ether has been given. Sound is propagated through the particles of matter, and without their presence and action no impression is made on the ear. A bell hung in a vacuum cannot be made to give forth sound. The necessary motions may be produced in the metal by means of a hammer attached to clockwork; but these find no means of transmission outward, and therefore are not transmitted, are not conveyed to the ear. Light, on the other hand, passes through a vacuum with the greatest facility. It finds in it, after the air has been withdrawn, a medium of its own ready for perfect action. It also passes through space, hastening to us from the most distant stars, through regions where atmospheres cannot be said to exist. There must, there-

fore, be everywhere a special element which forms the vehicle for carrying from point to point those energies or motions which are light-giving. This element, this ether as it has been called, does not make its own existence known to any of the senses. We do not see, we do not smell, we do not taste it. It emits no sound. In no way, even in its most rapid light-giving motions, does it affect the sense of touch. We do not perceive it by any of the means through which we become acquainted with the existence of the elements of the chemical world. The evidence, however, for its existence and mode of action in producing light is irresistible. It is strengthened and confirmed by such an element being necessary for the explanation of the phenomena of heat and electricity. As light reaches us from the most distant nebulæ, a vast ether sea must fill the whole of known space, and be continuous and the same throughout all its borders.

The undulatory or wave theory may be illustrated by what takes place when a stone is thrown into water. The molecules struck are borne downward, and the level is broken. The force of gravity comes into play, and acts until the surface again becomes a horizontal plane. Under its influence, the neighbouring molecules descend to fill the depression caused by the stone. The next molecules descend to fill their place, and the next move in like manner. This goes on till those at the point first depressed rise above their former level, and an elevation is formed. This again descends, and an elevation appears around it. Up and down the molecules rise and fall, through shorter distances each time, till equilibrium and a level is restored. Meantime the neighbouring molecules have been moving up and down in the same manner, and this movement has been propagated through the water, and so waves have been made to circulate all

around. The appearance is as if the water were advancing, as if it were rushing along the surface; but there is no such advance. A piece of wood floating on it simply rises and falls in its place, and shows very little motion forward, as it would do if there were a real onrushing of the water. When a molecule has ascended above, and descended to the point from which it started, when it has thus made a complete vibration, it has around it a complete wave, consisting of a crest and a depression. The wave it is, and not the water, that spreads and runs in every direction.

There is the upward and downward motion of the molecules, and the forward advance of that motion. Wave motion may also be illustrated by a rope fastened at one end and drawn sharply up and down at the other. In such a case it is easily seen that it is the wave motion, not the first part acted on, that runs along. According to the undulatory theory, light is propagated in this manner. Wave motions in the ether are created by the sun or other luminous body, are borne along through the former, and advance with extraordinary velocity, till they reach the pupil of the eye, pass through, strike the retina, run along the nerves to the brain, and on the perceiving nature associated with it produce the impression of light. The motions producing the impression are the transverse, or to-and-fro, up-and-down vibrations.

The exact constitution of the ether, whether it consist of minute particles or not, science has not certainly determined. We can therefore only speak of portions of it, and affirm that its action at points innumerable and infinitesimally small can be separated in thought, and spoken of very much in the same manner as if there were separate and independent particles. "A finite time is required to generate in a finite portion of it, a finite velocity, by means of a finite force." It is therefore

characterised by inertia, or resistance to force. Its inertia is, however, as feebleness itself. It is moved with unparalleled ease. To form waves, a change must also be produced in its parts; a strain must be caused of such a nature as to have in it a tendency to return to its natural relationships. It must therefore have elasticity. There are phenomena which show that its elasticity is of a peculiar nature, differing entirely from that of water, or of air, in the production of sound. We propose to show that its various forms of action are such as to manifest that, whatever may be its exact constitution, it is the work of mind. Its adjustments to material molecules also reveal the wealth of order that is in them. We shall consider it—I. In its action within itself; II. In its relations to material molecules.

I. *Its action within itself.*—(1) *Light travels in straight lines.*—The waves flow outward in all directions from any centre of disturbance, but each wave holds on its course, turning neither to the right hand nor to the left. There is no deviation of a single ray. All the rays that proceed from the sun, that are reflected by the moon, that come from the stars of heaven, run straight to their goal. In a vacuum, within any the same medium, the central points of a wave draw a line of inconceivable fineness and straightness. Every ray that comes from the sun draws such a line about 92,000,000 miles in length. And such lines are numerous as the rays of light in the universe. The first part struck in a line sends forward the force it has received to the next, and the next to the next, and onward, ever onward, from part to part, onward, ever straight onward, the right point in front always receiving the advancing energy. The least deviation near the sun would mean, at the end of millions of miles, an immense distance from the

straight course. A single disorderly point in a line would cause disorder. Were there several, the ray might be stopped, or turned far aside, or even back to the point whence it came. But nowhere is disorder found. How much this tells us of the ether, of the perfection of its sameness in sensibility to force, in elasticity, in exactness and accuracy of operation, in adaptation for work of nicety indescribable. A variation the smallest would have told. The minutest difference would have caused deviation. But there is no deviation, no turning aside. Every line is a wonder. It is said that a great artist, calling on a brother of the craft and not finding him within, drew a line which at once made known to his friend, on his return, the personality of his visitor. It was such a line as only one hand could draw. It had *that* in it which belonged to one hand alone. And lines of light have in them distinction incomparably higher, and must belong to a mind incomparably greater. It is comparatively easy to hit a mark near at hand. It is much more difficult to do so afar off. Who has not read with admiration of an archer cleaving a willow wand, of a rifleman from a distance many times piercing a centre. Clear must be the eye, steady the nerve, early and long the training, firm the will, and strong the directive power, that rise to the achievement of the greatest triumphs. The beams of light that fall on a flower of the field are, as if they were arrows from a bow, pellets from a rifle, aimed from the sun, aimed straight at that flower. This is cleaving the wand at the distance of many millions of miles; this is piercing the centre unparalleled. Never was aiming like unto it. Drawing of straight lines like these is far above the power of man. A hand of indefinite length, a hand guided by mind, possessing perceptive power, clear and minute

in fineness as the ether itself, and swift with its swiftness, might draw such lines; but that an ether sea should be so constituted, that all its parts should correspond so perfectly, as that it in its action should everywhere draw them, excites the very enthusiasm of admiration, the very ecstasy of wonder.

This law is of vital importance. Were rays not to proceed with perfect regularity in lines perfectly straight, were there disorder in the ether such as would intercept or bend them largely, the vision of things would be a scene of confusion. A thin pane of glass irregular with an irregularity not observable on looking at itself, is yet sufficient to mix up the objects in a prospect, to displace houses and stacks and trees and portions of grass fields and heath, and show the one where the other ought to be. Were the ether imperfect in places, the same minglings might result both on earth and the face of the sky. But of such minglings there are none. Every view is shown to us by lines of light of inexpressible straightness. And if it be said that there may be bending infinitesimally small, that bending must be the same in all. How much this tells of the ether! How is it glorified through all its extent, an extent not like a thin pane of glass, but reaching unto outermost existences! How resplendent are its samenesses in all even its minutest parts! How does every part and all parts, how do lines so multitudinous, so extended, and each one so perfect, speak! How loudly! How clearly! How they mean! With what brilliancy, with what overmastering intensity. To the very deaf how can they be silences? To the unintelligent how can they be meaningless?

> "A primrose by the river's brim
> A yellow primrose was to him,
> And it was nothing more."

But where can the leaden dulness be found, to which lines of light are lines of light and nothing more, suggesting nothing, revealing nothing, inspiring no deep ponderings, compelling no questions, rendering no answers? To the lips of every one there must surely spring the question, Does such an entity exist by chance? And is not the answer easy? Is it not a mighty triumph of mind? Does not every line, do not all the lines, carry in them irresistible evidence that the ether so ordered is the work of understanding; that so vast a sea, acting at every point with a perfection which baffles the imagination to realise, has its form and constitution as the fruit of the operation of an intelligence glorious as the glory of those fruits?

(2) *The velocity of light.*—The velocity with which light travels is nearly a million times greater than in the case of sound. It descends from the sun to the earth in about eight minutes and a half. In one minute it makes 11,160,000 miles; in a second 186,000. In a second it would circle round the earth more than seven times. Observations have been carefully taken, and in a vacuum and in air no difference can be detected in the velocity of light of any colour. There is, however, a difference in their velocity, passing through water and other transparent substances.

The velocity with which light travels shows the extraordinary sensibility and perfection of the ether. In the journey of a single line of light from the sun to the earth, how much of it is moved in a second, how much in a minute, how much in its whole course! And every part at every point is distinguished by the same readiness to be moved and to move. Every part is distinguished by an elasticity many hundreds of times greater than is found in steel. Every point is characterised by exactly the same measure of elasticity. Nowhere is there hin-

drance, obstruction, or retardation; nowhere the semblance of irregularity, the least touch of disorder. Every part is equally suited for the work assigned. And thus the progress of a single ray affords abundant evidence of the presence of mind. And every ray bears the same testimony. Every ray that comes from the sun proclaims the order which it finds in this wondrous sea. And every ray that comes from the most distant star declares that at every point in its travels it has found a welcome, it has been sent forward and received a God-speed, and no let nor hindrance in any the most insignificant measure. This glorious medium forms one mighty sea, one magnificent machine. Behold, cry all parts of it from earth and heaven, behold our unity. We are extended through spaces vast and beyond all measures. But behold how we act together, respond to, and are true to each other throughout all our borders. There is not an indolent, there is not an inefficient, there is not a disorderly part among us. We are everywhere perfect, everywhere efficient, everywhere ready for action, always ready. And where is there action like ours? Where can motions be found rapid and beautiful as those which we are ever executing? And we made not ourselves. We determined not our own nature. We measured not our sensibility and elasticity. We created not the perfection of our harmonies. We are the children of mind. We are the work of understanding.

The suitableness of the velocity of light is remarkable. In a minute it travels more than 11,000,000 miles. In the same time sound does not travel thirteen. Had light been conveyed at the same rate as sound it would have taken a day to advance 18,687 miles, and would have been nearly ten days in passing over the same distance as it now covers in a second. It would have needed more

than thirteen years to come from the sun. Such a velocity would have had no suitability in it. Ten times, a hundred times, a hundred thousand times, that velocity would have had none. But it is nearly a million times greater and most suitable. It is transcendently great, and of that greatness which its usefulness in an ordered kosmos demands, of that greatness which the distance it has to travel requires. Its velocity is determined for the work it has to do. The velocity of sound is suitable for it, and that of the advance of the waves of light is suitable for them. It is measured and adjusted and set at a point where it proves an invaluable factor in the arrangements of a universe. And this measure of the velocity depends on the constitution of the ether. Its essential nature has therefore been fixed by mind, so that its motions might advance with the remarkable and fitting rapidity which characterises them.

Velocity of advance by waves is a wonderful design both for light and sound. Notwithstanding their smallness, the molecules of air when set in motion in a hurricane at the rate of a hundred miles an hour, sweep on with a force that causes great destruction. If Newton's emission theory of light had been true, what must have been the nature of the particles emitted, which, having an onrush not of a hundred, but of hundreds of millions of miles an hour, would yet beat on all things, and not exercise any force that can be felt, but be gentler than the gentlest zephyr? Such particles, if material at all, even if immeasurably smaller than the smallest molecules, proceeding at so enormous a rate, and being in numbers so vast, might have been expected to blow worlds before them. And without mind at the helm, there might as well have been such a roar and rush of particles as the state of things which now exists, rendering calms impossible, and

making all nature a whirlwind of whirlwinds, to which the mightiest hurricane even of a thousand miles an hour would have been but a light breeze. But whatever may be the constitution of the ether, in the advance of wave motion, no perceivable force is exerted. Air wave motions, generated by lightning, strike the ear as loudest thunder, but not as gentlest wind. And so light and colour and sound are conveyed in such a way as to be themselves perfected, are conveyed with a velocity transcendently great, and yet do no harm, are conveyed with the wisdom of the serpent and harmlessness of the dove. *They are a divine solution of the problem, how to obtain the maximum of forward velocity with the minimum of forward force.*

The waves.—The order which reigns is still further illustrated when we consider the waves. They are measured; they are of different lengths, yielding the seven colours. The waves of the same colour are of the same length. The ether is so perfect in its action that under the influence of the energies beating on it, it forms throughout the waves of red of their special length, and of each colour of its special length. In every line of light stretching from the sun to the earth or coming from the most distant star, the number of waves is proportional to the distance traversed. In numbers so vast this is surely a most impressive fact.

The wave lengths are so accurately measured that it has been proposed to adopt those of one colour as affording a perfect standard of measure. Nothing is more difficult to obtain than such a standard, one that shall be exact, and continue the same for all generations. Science has been called into play for the devising of it, and the French determine the length of their metre from the dimensions of the earth; the British our yard from the second's pendulum. Both these, however, would be

affected in the course of ages. But nothing affects, or ever can affect, the length of a wave of any colour of light. Nothing can ever increase or diminish the line occupied by any definite number. They have been measured, and their length can always be so exquisitely determined as to render them a practical and perfect standard of length. They would suffice for all lands. A scientist in Britain, France, China, and Australia, in Jupiter, Mercury, Neptune, or any planet revolving round any sun in the universe, would be able to make a yard or metre, differing no not by a hair's-breadth. So exquisitely is the ether made throughout all its borders.

Let a sphere be drawn round the sun at any distance. Count in every line of any colour of light a million billion waves, and the points where the numbers are completed would form a sphere as perfect as the first. Let there be two spheres and a million miles between. In every line of that length, of a million miles, there would be in the same colour the same number of waves. We cannot of course prove this by experiment, but experiment leads us to the conviction that it is true, and this mode of representation enables us to realise that the measuring of the waves is immeasurable in amount and inconceivable in accuracy, shows a splendour of order inexpressible. We can go a great length, and so as to see that they are formed by a hand, oh, how perfect! a hand that loves absolute perfection, aims at it and is able to secure it, and that if in any line of any length there is one more than belongs to that length, there is a reason for it. Yes, there is a reason for everything in the works of the mind that made the universe. Are there perturbations in Uranus, then, reasoned the astronomer, there must be another planet beyond, and by them that planet was placed and found

in its place. Is there, may we not say, one more wave in any length of line in space more than in the same length of all others, then is there a reason for it. The multitude therefore of the waves and the exactness of the measuring can have but one glorious meaning.

The transverse vibrations to which light is due have also been numbered. The ether vibrates 395 billions of times in a second in producing red light, 509 billions in creating the impression of yellow, and 763 billions that of violet. These numbers are enormous, widely separated, and comparatively definite. In a single ray, stretching from the sun to the earth, how multitudinous are the vibrations, how enormous the number in those that fall on a field, on a great plain, on half the earth, that proceed from the sun in every direction, that are in the vast ocean that stretches from sun to sun, from system to system, from nebula to nebula. And at every point the action of the ether is exquisitely perfect. Can anything be imagined more impressive than so vast a unity and uniformity of action, any fact of mightier significance? Is not orderly working so extended, so transcendent in fineness, an overwhelming wonder? So great a multitude of points, acting so exactly alike, vibrating with a velocity so extraordinary, and yet so perfectly measured, fill the universe with the sound of one unmistakable testimony to the source from which the ether has come, to the Intelligence by which it has been made.

Lines of light, by the action of their waves, and transverse vibrations, do the finest work. They show the most charming colours which exist, the finest forms that are. The greatest artist that ever with brains drew his lines or mixed his colours, that produced masterpieces admired of all the world, could have done nothing but for the perfection of their action. Because of it he was

enabled to perceive clearly what he himself was producing, and because of it beholders could behold, and be lost in wonder and admiration. Let the man of genius do his best, let him attempt the greatest things, striving with all the power that is in him to idealise and to realise his ideals, he will find in the waves of light assistants and co-workers that respond to his conceptions, that enable him to see and paint, and that make visible to the kindred eye the supremest beauty that he can place on canvas. Yea, he is not altogether worthy of them. They can do better work than any which his genius require at their hand. Who can paint like nature? There are forms which no artist can limn; there are colours which no genius can match; there are faces and expressions and beamings which no human hand can represent, but there are none to which the waves of light cannot do justice, none which they cannot convey to all who can see. There is no fineness of work to which they are not equal, for which they are not sufficient. Let any beauty be found in nature, in garden and landscape, in enlarged and grandest view, in sunrisings and sunsettings, in graceful form and glowing face and beaming eye, the ether waves and vibrations will convey it, and present it to the onlooker with all its charms.

V

LIGHT—THE ETHER IN ITS RELATIONS TO MATERIAL MOLECULES

Sources of Light—Reflection—Refraction—Scattering—Absorption—How Colours are produced—The Ether made for the Illumination of the Universe—The Finest Test of Order in the Atoms and Molecules—Does the Finest Work.

II. THE ether in its relations to material atoms now falls to be considered. Aggregates and combinations of matter form the ordinary sources of light. In such a source there are two parts, and two modes of operation. Chemical action produces heat motions in the ether. These encountering solid matter are changed into motions that are light-giving. To obtain a lamp, it is not sufficient to raise heat of proper intensity. Another contingency enters.

Both requirements may be illustrated by what happens in lighting a petroleum lamp. When first ignited its flame is dull, and much smoke is given forth, much carbon, not finding oxygen atoms with which to enter into combination, escapes. The glass chimney causes a draught. Oxygen is thus supplied in larger measure, more of the carbon combines with it, the temperature is raised, and, what is as important, a sufficient supply of solid carbon remains in the flame to cause luminosity. To produce the motions that are light-giving, there must not only be atoms and molecules acting with burning

energy, but also a sufficient number unconsumed. There must be carbon entering into combination and raising a high temperature, and there must be carbon not entering into combination, and the action of both produces light of proper intensity. Magnesia or lime, being infusible and incombustible, placed in a flame of intense heat, gives forth a brilliant light. The most dazzling illuminant that can be produced is that of electricity passing between carbon points.

A lamp, we say, or sun, is an instrument of two divisions and two modes of action. In the one, chemical action creates heat motions in the ether. Against the other, which to it is as a stone wall, these heat motions dash, and spring back not broken and destroyed, but glorified and glowing with illuminating power. But for the existence of matter capable of chemical action, but for its adjustment to the ether in two different ways, it would, in the vastness of its extent, in the beauty and perfection of its order, and in its adaptation for work of extraordinary usefulness and fineness, have existed in vain. That it has being, and that atoms also exist, of such a nature, and so adjusted to it, and in such multitudes as to bring it into glorious play throughout the most extended regions, cannot be by chance, but must be due to mind.

If we venture to look toward the sun, or fix our eyes on a lamp, rays of light come to us in a direct line. We see them beaming; they dazzle us by their brightness. Other beams reveal themselves only when they strike solid objects. Rays passing into a room show their splendour on floor or wall, and also mark their course by lighting up the dust they encounter. Were they to show their lustre in passing through the air; were their relations to the oxygen and nitrogen of the atmosphere such

as to colour them as they do many gases, or to light them up as the dust in a room; were they to fill the spaces through which they pass with brilliancy, we would find ourselves in the midst of a sea of light which no eye as at present constituted could bear, and which would obstruct the dimmer rays coming from material objects around us, and hinder them from being seen. We would see nothing in such a case but lustre; lustre, lustre everywhere, and not a thing to see. But how perfect is their real action! How admirable is the adjustment that they should not show themselves directly, or reveal the molecules of the atmosphere! Their activities are not of themselves. They cannot generate their own action. For this they are dependent on molecular forces and motions of two different kinds. And their existence is not for themselves, that they may be seen, but for matter, that it may be seen. Light is not that which is manifest, but that which makes manifest. Without solid matter to reveal, even the light is darkness. Is such an adaptation the work of chance? Has a medium without meaning or use in itself, a medium characterised by matchless perfection of action, and filling a vast immensity of space—has such a medium happened to exist, and in a condition exquisitely fitted to minister to other entities and be an instrument by which they might be glorified and their glory revealed, in a condition in which everything that would hinder their usefulness is guarded against? Is it as if an immeasurable intensity of thought and minuteness of care had been bestowed on every part of it to adapt it for the finest and most wonderful work, and yet is all the result of chance? Impossible, absolutely impossible, is such a solution.

When rays of light fall on material objects, they are either reflected or refracted, scattered or absorbed. The

mode in which they are affected has been illustrated by the action of elastic balls. If a number of them be arranged in a line, if they be of the same size, and the first be struck, it would give up its whole tendency to motion to the next, and would itself come to rest. The second would act in the same manner, as would also the third and the fourth and the fifth, and all in the series. But if two series be placed in a line, the one heavier than the other, and the first of the lighter be struck, the action would be the same as before until the impulse reached the first of the heavier balls, when it would encounter a stronger force of resistance than before, and so, while giving up its whole motion forward, the lighter series would receive an impulse and motion backward. In some such way are rays of light affected, and the energies in the ether made to pass on wholly or in part, to divide and bend according to the resistance encountered.

Regular reflection.—Light falling on a mirror, as of water, mercury, or any polished surface, does not wholly enter it, but is partly bent back in a new direction, or reflected regularly, and partly reflected diffusely, or scattered. The angle, which the line of the reflection of a ray makes with the perpendicular to the surface of a mirror at the point of incidence, is termed the angle of incidence. That which the reflected ray makes with the same perpendicular is termed the angle of reflection. These angles are always in the same plane, and are equal. They can be measured by an instrument, the graduation of which is as perfect as it can be made, and there cannot be discovered the least turning aside from the plane of incidence; there cannot be discovered the least fraction of a degree of difference in the magnitude of the angles. In passing from point to point, from any point in the

line of incidence to any point in the line of reflection, a beam of light chooses the shortest course, follows the path in which it will make the journey in the shortest time. The waves of a ray of light dart on a mirror, strike it and rebound, imparting the larger portion of their reflected motion to the ether lying in a line drawn in the plane of incidence, and making with the perpendicular an angle equal to the angle of incidence. On the parts near the mirror everything depends, and never do they fail, never do they act disorderly. They are always true to their kind. They know in what direction to forward the energy they receive, and initiate a new wave in the right plane at the right angle. There is not a point of the ether that would hesitate for the infinitesimal fraction of a second, that would not with the same quickness make the same choice. Such perfection of action is too wonderful for us, too clear in its meaning to leave room for mistake. It makes evident the perfection of the sameness of the ether throughout all its borders.

Refraction.—When light falls on a transparent substance, a portion enters and passes through. It takes, however, a new direction, and is bent or refracted towards the perpendicular. The size of the angle of incidence bears to that of refraction a constant ratio. For the same substance it is always the same. For different substances it is different. Its velocity is also affected, but always in the same measure in the same substance, and in different measures in different substances. In the midst of aggregated molecules the ether cannot vibrate with the same ease as in a vacuum. It is hindered. The direction of its rays is changed; the velocity is diminished. The molecules take away from the energy and bend the action into a new line. But all the molecules of the same substance act on it in the same manner and measure.

The ratio of refraction for various transparent substances when the light passes through them is as follows:—Water, 1·333; alcohol, 1·365; brown glass, 1·530; diamond, 2·487; air, 1·000273; nitrogen, 1·000300; chlorine, 1·000772. The order which pervades all substances is thus put to a test of extraordinary delicacy. The relationships of molecules of water to the ether are so exquisitely adjusted that the effect of the former on the latter is uniform. The similarity of molecules of water, the regularity that pervades them, could not be more finely tested, more clearly and triumphantly held forth to view than by their thus exerting the same influence on an entity of sensibility so high. The sameness of that sensibility is also made clearly evident. The characteristics of both forms of being are determined with a minuteness of likeness so inexpressibly perfect that the effects which pass from one to the other are constants, that show not an infinitesimal smallness of variation. Intelligence has left its impress on every molecule of transparent matter, on every part of the ether.

Refraction of different colours.—A ray of white light is not simple. It is the advance, not of a single wave, but of seven, giving the red, orange, yellow, green, blue, indigo, and violet hues of the spectrum and rainbow. Each ray and colour has a different refractive index, and so when white light is passed through a prism they are bent in a different measure towards the perpendicular, and are separated. This is beautifully shown, not only by the spectrum, but with homogeneous light. Lithium, sodium, thallium, indium yield for the most part homogeneous colours,—lithium red, sodium yellow, thallium a splendid green, and indium blue. When the light of their flame is passed through a prism it is deflected, the yellow of sodium more than the red of

lithium, the green of thallium more than the yellow of sodium, and the blue of indium more than the green of thallium. If the four metals be mixed in the flame, no definite tint is produced. The colour is indeed almost white. But pass this light through a prism, and again each colour appears in its purity and beauty and in its own relative place—red, yellow, green, and blue. The colours differ in the length of the waves and in the number of the transverse vibrations. The ether occupying the space among the molecules passes on every kind of wave, transmits the seven different colours. The molecules and ether are, however, so adjusted to each other that the action of the former on the latter bends each colour more and more. Each wave has its own length and number of vibrations, and its own susceptibility to the action of the molecules, has its own measure in which it is bent towards the perpendicular. Each wave of the same kind, anywhere and everywhere, passing through the same substance, is always deflected in the same measure. The substance of the prism, consisting of ordered matter, tests and exhibits the action of the ether in seven different kinds of ways, and bears a sevenfold testimony to it as produced by mind. Whatsoever differences of action they may show are all found to be in harmony with law and order. But were not the molecules and the ether perfectly ordered they could not exhibit order in their action. Were they not made according to one exact and adjusted pattern they could not obey one perfect law.

Diffuse reflection or scattering, and absorption.—Non-luminous bodies can only be seen by light falling on them from those that are luminous. Rays striking any point are partly stopped and partly spring from it, and fly to every quarter far and near. By these latter

the moon and planets and all visible objects are seen. Looking at a lamp or the sun reflected in a mirror or in water, the part of the mirror or water where we see the waves reflected regularly can hardly be seen because of the largeness of the portion so reflected, and the comparative smallness of the amount scattered. General objects are easily seen, because the light which shines on them is largely scattered.

The colour of the rays scattered is determined by the power which substances possess of absorbing some and dispersing others. Were all the rays which fall on the objects of nature scattered, they would be of one universal whiteness. But in different substances there is the power of absorbing certain rays and scattering the rest. This absorbing power is brought clearly into view by transmitting the colours of the spectrum through transparent substances, when it is found that each has colours which it allows to pass, and others which it arrests and absorbs. Nitrous acid gas allows the red end of the spectrum to pass, but stops the rays towards the violet end. It is thus shown to absorb the latter and scatter the former, and therefore it is of an orange red colour. When the vapour of iodine is treated in the same way, the orange, yellow, and green rays are arrested, and only the red, blue, and violet are transmitted. The latter only can therefore be dispersed and form the lovely tint of that vapour. Permanganate of potash arrests the yellow and green, and its reddish-violet colour results from the mingling of the others. Potassium bichromate absorbs one part of the spectrum, ammoniated oxide of copper the other, and light passing through both is completely taken up, and so the second is black. If a spectrum be thrown on red paper instead of white, the yellow, green, blue, indigo, and violet are absorbed,

whilst the red and orange are almost as bright as on the white. If yellow, green, or blue be employed it will be found that each disperses its own hue and absorbs the others. White paper shows all the colours of the spectrum, because it scatters all. Black is black because all the colours are absorbed. No part of the spectrum can be seen on it. A colour is destroyed when it is wanting in the light shining. The yellow flame of sodium does not contain the red rays, and therefore when beams from it are thrown on red paper, all the rays of yellow are absorbed, and there are no red rays to scatter, and therefore the paper is black. Were the sun a glowing globe of sodium yielding only yellow light, no variegated beauty would deck the earth, no lovely flowers would adorn the gardens and fields; its hills would know no rosy light, no purple heath, its fields no mantle of living green. All things would be yellow or black. Those would be yellow which scatter the yellow, and those black which absorb it. Sunlight is made up of all the colours of the spectrum. The substances burning in the great orb of day create every variety of wave. The light of gas and candles also contains all, but not the same proportion of each colour. The yellow is more abundant than in solar light, the blue and violet less abundant. It is for this reason that it is difficult to distinguish blue and green in candle-light, because green materials contain blue rays and blue materials green rays; and when the blue rays are diminished in numbers, as they are in candle-light, there is not the same clearness of distinction.

Three conditions are therefore necessary to the production of any colour. First, that its waves should be found in the illuminating light; second, that the substance on which the light falls should be capable of absorbing the

other colours in it; and thirdly, of dispersing that colour. In plants there is a substance called chlorophyl, which has the power of absorbing part of the red and most of the violet rays, leaving the extreme red, orange, yellow, and green in considerable brilliancy. Their green colour is not therefore simple but compound.

The causes of absorption and scattering of colour are very wonderful and very beautiful. The atoms of different substances have their motions and capacities for motion, and those waves are absorbed which fall on them, and are in such relationship to them that they can take up their motions, while those are scattered whose motions they cannot take up. It is as when taps are timed to the period of the swing of a pendulum, and, being so timed, increase the oscillation, but not being so timed the object tapping is sent out. Here then is a magnificent and minute adjustment between the atoms of matter and the ether. The capacity for motion of the one is in its various measures arranged with reference to the other. There is not an atom of matter, there is not a point in the ether, that is not thus adjusted. As far as the ether is concerned, and if chance only had been in the field, there might not have been one atom of matter having motions such as to absorb a single kind of wave, and the motions of the ether might have been such that no absorption would have been possible, and, in such a case, the variety of waves would have been valueless, the earth would have lacked the colours and tints that make up its beauty, and would have been of one hue. But the amount of adjustment for absorption is enormous, and enables the earth to be clothed with loveliness of endless variety. The molecules in grass, which give to it its green colour, have their motions so arranged that they can receive and swallow up so many motions of rays

falling on them, as to reflect irregularly a glowing green. The heath of the mountains has in its lovely bells molecules which take up so many kinds of motions of the waving ether and reject others, as to be able to clothe the hills with purple. The flowers of the garden and the field have their atoms so ordered as to give forth all the colours of the rainbow. The same flowers glow and beam with several hues.

The scattering of rays is all-important in the economy of nature. It is by it that objects are seen. Of the beams of light falling on a blade of grass, those which the atoms cannot take up are sent out in every direction in which a straight line can be drawn from the surface. The last points of the ether strike against the constituent molecules in the grass and flowers, and give up those energies which these can receive, and recoil with those which they cannot receive, and generating motions of the same kind in every finest line that proceedeth from them in any direction. How inexpressible is the delicacy of the work thus performed! How great is the amount of it!

No great and extensive work can be accomplished by haphazard means. To obtain a powerful machine, a mighty engine, requires long, deep, and earnest thought. The most important machines of modern times have not been perfected at a stroke. They have been at first clumsy and complicated. They have worked awkwardly, and have needed many arrangements and corrections to render them serviceable. The perfection of an instrument lies in simplicity, in adaptation for work, in power of smooth and effective action. It is when great principles are brought into play, when mechanism in harmony with them is constructed, that an end sought is best reached, that an object aimed at is most successfully accomplished. It is also true that no great work can be

done, no powerful mechanism can be devised, unless there be great laws and principles, and the most beautiful and ordered relations, in the substances with which it is necessary to work. Mind cannot set in order that which is not susceptible of order, cannot adapt that whose own fundamental nature does not render it adaptable.

The illumination of the universe is a vast and marvellous work. It is accomplished with ideal perfection. Nowhere is there a flaw, an imperfection, or a hitch. It is done with charming simplicity, with magnificent ease and smoothness of working. It is indescribably great. An ether element fills all known space. The sun of our system, and suns in billions, form centres of force, which act upon it, and create light-giving waves. These travel with a velocity of 11,000,000 miles in a minute. They advance in straight lines, so that there is no straightness like theirs. Each point of the ether vibrates transversely hundreds of billions of times in a second. Each colour has its own special number of hundreds of billions. The number of beams striking a surface small as a leaf cannot be told. The number beating on half the globe is enormously beyond every form of expression. Yet even they are few compared with the multitude sent forth from the sun. And every sun of the multitude existing is doing the same work. And at every point the great ether sea plays its part with a faithfulness unsurpassable.

And when the rays of our sun reach the earth, they do not spend their strength in revealing themselves, they do not make the molecules of the atmosphere to glisten or glow with colour; they make manifest the matter of the earth. They are in many ways adjusted to its molecules, so as to be reflected, refracted, scattered, and absorbed. The various elements and combinations are differently adjusted for the ether action, so that by most

substances a portion of the rays is scattered, and a portion absorbed, and the scattered rays are enabled not only to make manifest all objects, but to reveal the variety which distinguishes them. Thus is the earth flooded with light, bathed in splendour, decked with loveliness. Every form of matter of sufficient density affects the rays which fall on it, and sends them from it with its own message, compels them to speak of it, and show its characteristics to the eye of every beholder. With what perfection is this accomplished! With what order do the countless messages from an extended prospect pass through the air along the ether, enter the eye and by the retina and nerve fibres give in their report. From a mountain top we may see a hundred hills, a thousand fields, out to sea, many woods and streams, houses and roads, horses, cattle, and sheep, men and women, while the sky looks down on us a calm ethereal blue, or shows clouds of various tints. From such a prospect how many waves spring, how many beams flow, how many motions enter the eye! They are every instant numerous as the dust of a mighty mountain, as the sand of all the seas. And yet, crowded as they are, crowded and packed as nothing surely was ever crowded and packed, they pass in all their mighty multitude through the little opening of the eye without the least approach to disorder. They keep their place, dart straight to their goal, and deliver up their message. And these messages have not only been borne from all quarters to the one point from which we have supposed them observed, but to all other points within their range. What mingling are here! What crossings in every direction! What billions of billions of waves passing in the smallest space, passing without jostling or interference! What a sea of rapid, beautiful, and orderly movement! Every colour within view is re-

ported on by its own number of vibrations. The green fields, the woods and streams, and houses, and living forms arrest for an inconceivably minute fraction of a second the rays that fall on them, but in that fraction of a second they have moulded them to their will, they have shorn them according to their fashion, they have made them their servants, they have sent them on their errand, and long before the second is over, if we may use such language, their errand has been run, their message has been delivered. What magic is here! What work is accomplished! What journeys are made! How lightly are burdens taken up! With what speed they are carried! With what accuracy they are delivered! This is surely the perfection of burden-bearing, the very grandest triumph of message-carrying.

And the universe is filled with such work. And everywhere the same perfection reigns, the same brilliant order holds the field. Over the whole earth, throughout the heaven of heavens, there is not a touch of chaos. Rays come from the moon. From the planets they make their way to our planet. They pour down from the sun. They descend from the most distant stars and star clusters. No distance is too great for them to travel. They faint not, neither are weary. They journey through space for thousands of years, never relaxing their speed, but darting onward, ever onward, till they are perchance arrested by some world to which they deliver up their message. Can then any machine, instrument, or agency be compared with this? The work done is enormous, beyond the power of words, illustrations, or imaginings to indicate even an insignificant part of it. It is accomplished with ease, smoothness, and exquisite perfection. The widest principles, the most beautiful laws, the simplest arrangements are seen in it. Is then the ex-

istence of such an instrument due to chance? Is a machine so vast and perfect the work of haphazard? Is it by merest accident that a sea so extended and so fine, of a nature so different from ordinary matter and yet in so many ways measured and adjusted to it, a sea so exquisitely adapted for the illumination of the universe—is it by merest accident that such a sea has being? No sane mind can believe absurdity so extreme.

Considering the ether sea as a whole, how great and marvellous it is! Its vastness astounds. Its nature, continuity, and sameness through all known space amazes. Its modes of action within itself, and in its relationships to ordinary matter, transport with admiration. The great Apostle of the Gentiles speaks of an hour in which he was caught up to the third heaven and heard words not to be uttered on earth. The things of that celestial region needed a language of their own to express the magnificence of their glory. And such are the qualities of the ether, so far do they surpass those of ordinary matter, that the language which men have been accustomed to employ in speaking of the familiar things of the world, is but veriest feebleness when employed to set them forth. Its every quality is transcendent. It is of transcendent fineness. Choose we those threads that are finest as of silk or gold, what are they but grossness compared with sunbeams. Its elasticity is transcendent, hundreds of times greater than of spring steel. The velocity of its forward and transverse motions convey to the mind an overpowering sense of the measure in which in this respect it goes beyond the action of any kind of matter. And yet widely separated as it is from atoms and molecules, its every property is adjusted to and measured for them. Its qualities are in every respect collocated at the right point, to enable it to minister to

them, to render them service necessary to their usefulness. This wondrous entity fits into a wondrous place in the order of the universe. How overmastering is the evidence that it is the work of mind! How impossible that entities so different and yet so necessary to each other's action and efficiency should have happened to exist from eternity in measures and numbers so enormous and so minutely and variously adjusted to each other.

The ether medium does not exist for itself, and it is as certain that it does not exist in order so dazzling of itself. It ministers to ordinary matter, and by the glory of its ministry makes known the mind from which it has come. It makes manifest matter. It makes manifest mind. It reveals things seen. It reveals things unseen. It illumines the universe with physical light. It shows it filled with the light of an understanding in which is no darkness.

The relations existing between the ether and the molecules reveal their order also and the perfection of their action. We have seen that the ether is so constituted that its motions are not reflected diffusely by the nitrogen and oxygen of the atmosphere. It may be as justly argued that the molecules of these gases are so constituted as not to reflect them in this manner. Other gases are of various colours, but they are of no colour. Not a molecule of either of the two forwards any impression to the eye. How important this is it is easy to see, and how fine the adjustments involved it is not difficult to perceive. The molecules of chlorine, on the other hand, are so adjusted to the great medium, the motions of all are so similarly determined, that they absorb the same waves and scatter the same. They therefore resemble each other exactly in those characteristics on which the

absorbing and scattering of waves depend. The chlorophyl in grass and other vegetables has the motions of its molecules so timed that they reflect prevailingly a vivid green. The dazzling yellow of furze and broom, the brilliant loveliness of flowers, fruit-tree blossoms, and purple heath tell of molecules beautifully ordered and adjusted to ether motions, so as to enable them to glow with these colours. They are put to the test by a most delicate touchstone, and are not found wanting.

The molecules also of each substance in the midst of heat motions have their own waves to which they give birth. Those of carbon create all the waves, and so yield white light. To do this they must have so many relations to the medium; there must be so many characteristics in their own form and motions as enable them to affect the ether in seven different measures, producing the seven different numbers of billions of vibrations. As carbon is the great source of artificial light on the earth, is it not very remarkable that it should be so richly endowed as to be able to bring into play all the capacities of the ether? The molecules of lithium transform the heat motions into the vibrations of red light only, those of sodium into the vibrations of yellow light, while those of thallium and indium produce the billions which yield green and blue respectively. The molecules of lithium are thus shown to possess such energies and motions that when the heat waves are dashed against them they raise the number of their transverse vibrations to 395 billions. All the molecules of this element have their powers in this respect thus accurately determined. Those of the other three substances have their powers in like manner exquisitely measured. What, then, has produced results so uniform? What has measured and adjusted the energies at work in the molecules of these four sub-

stances as that they might be capable in each case of raising to just so many billions of vibrations? The waves created by sodium are affected to the extent of 110 billion transverse vibrations more than in the case of lithium, while indium adds 263 billions more than in the case of sodium. Has it not then required the most careful measuring and adjusting in order to add with accuracy numbers of vibrations so great? The elasticity of the medium is so transcendent that slight differences affect it. What, then, can measure such differences with the necessary nicety? What can measure and collocate forces so exquisitely in entities of such sensibility? In the case of carbon, what could endow it with so many potencies? What can do these things but an intelligence of extraordinary perceptive, distinguishing, and practical power?

It is in lithium as if the teeth of a wheel and the rapidity of its motions were so adjusted to those of another as to create in it 395 billion revolutions in a second. How difficult it would be to make two such wheels! How difficult to find suitable materials and forces! How much thought and calculation and measuring would be necessary in the making! And if one were to find a multitude innumerable of such wheels, perfectly adjusted and working with inimitable smoothness and ease, would he say, What marvellous chances meet here! How wonderful that these should have happened to exist from eternity, so measured, adjusted, and collocated! Assuredly not. He would bid such a suggestion away from him with infinite contempt. In nature we have the likeness of such wheels; we have what produces like results. We have the molecules of lithium, sodium, indium, and the multiplied points of the ether. And these are so adjusted to each other that

every molecule of the three substances acts on the points of the other so as to fix the number of vibrations in it at 395, 505, or 763 billions. What then can we do with the suggestion of chance or blind evolution as sufficient to account for such phenomena but as in the case of wheels, fling them from us with infinite scorn. The existence of worlds of atoms and molecules and of an immense ether differing so widely from each other, and yet so admirably adapted in nature and action to each other, can only be accounted for by the one being made for the other by an all-powerful Mind.

VI

SOUND AND MUSIC

Causes — Media — Waves — Periodic Motions — Musical — Non-periodic—Noises—Waves in Air, Water, Earth—Reflection—Refraction—Velocity—Numbers of Waves—Length—Vibrations of Strings—Rods—Plates—Bells—Resonance.

THE eye and light are the means by which we are enabled to move to and fro on the earth, to work safely and skilfully. By the ear and sound intercourse is carried on between man and man. The laws of light have afforded many arguments in favour of the making of the ether by which it is transmitted, and also of the molecules of matter for which its properties are measured, and the order in which it puts to the finest test. The laws of sound, the modes in which it is originated and conveyed, contribute also a rich quota of facts sustaining the same contention.

Even in the infancy of scientific investigation, a true, though necessarily vague, idea of the cause of sound was formed. The language of Aristotle is such that, as has been said, admirers in their enthusiasm might, without much difficulty, draw from it a pretty full and accurate account of the manner in which it is produced and propagated. That it is caused by the motions of a vibrating body borne through the air to the ear was universally held. At the same time the nature of the motions was unknown.

Production of sound.—Any body made to vibrate is capable of producing the sensation of sound. Any kind of blow, as a hammer striking a nail, the explosion of a rifle, a flash of lightning, a bow drawn across a string, a reed agitated, any force acting so as to produce vibrations in sufficient numbers creates sound.

A medium of conveyance is necessary. Where there is nothing to strike or be struck, there can be no emission of sound. Where there is nothing to receive or convey the motions produced by a stroke, they cannot be conveyed. A glass jar is made to rest on the plate of an air-pump. Within it is a bell associated with clockwork. The jar is emptied of air by exhaustion. By means of a rod descending into the glass, the detent holding the hammer is loosed, the hammer strikes the bell, and sound motions are created in it. But as there is no air to receive and forward them, they are not forwarded. They cannot therefore be heard. Putting the ear to the jar, a dull thud strikes it. The clock is hung by strings, and that noise passes through them to the outside. Were the air admitted, the bell would ring clearly.

Sound is carried by wave motions. Their characteristics have already been described in treating of light, and have been illustrated by those of water. In the waves of the sea, as we saw, the water does not advance, but the rising and falling. If a flexible string, fastened at one end, be held in the hand, and be drawn quickly to one side and back again, a wave will run along it. In this case it is very easy to see that the particles of the string do not run along, but the motions only. And so sound motions are carried, not by the first particles of air struck being borne forward to the ear, but by their striking the next, and they the next, and so onward. The first, moving forward a little, stop; they then return, and so oscillate to and

fro till they come to rest. The particles ordinarily being a little separated from each other as the motions advance, are driven on each other, and a condensation takes place, then, as they recoil, there is a separation and rarefaction, and this process is repeated, while the vibrations go on. The particles are made to vibrate, not in a direction transverse to the advancing wave, but in a line with it. The condensations correspond to the crests of the waves of the sea, and the rarefactions to the troughs. As the waves of water rise till they reach the greatest height and then begin to fall, so the particles advance till they reach the greatest condensation and then begin to rarefy.

All material particles convey waves. They are forwarded not by air only, but by hydrogen and all gases, water and all liquids, stones, and the firmest solids, iron, and every metal. Divers in the sea hear the waves dashing against the shore. Every wave as it strikes the sand creates innumerable motions in the air, the solid ground, and in the water. Sound runs easily through the sea. A bell weighing 800 lb. was let down about 20 feet into the sea through a well hole in a specially constructed vessel, the clapper of the bell remaining under the control of those on board the ship. When the bell was struck it was plainly heard in the hold of another ship a mile away. When it was replaced by a man and a speaking trumpet, listeners could hear at a distance of three miles. The earth carries sound. An ear put to it will hear the tramp of infantry, the march of cavalry. Sound waves pass also through stone walls, and along iron rods.

Waves are periodic and musical or non-periodic and unmusical. The motions of the pendulum of a clock are periodic. The times of its swinging to and fro are

equal. Periodic waves are those which follow each other at the same intervals, that execute their oscillations in the same time. When the waves succeed each other with sufficient rapidity, and at the same intervals of time, they make music to the ear. When they follow each other at irregular intervals, they produce a noise that grates on our sense of hearing. It matters not from what source the force originating the motions comes; if they be periodic, they are musical; if unperiodic, they are unmusical. From the finest instrument a confused jangle may be made to issue.

All simple sounds are periodic and musical. A noise is always composed of two or more simple sounds superposed on each other irregularly. A resonator is an instrument made to re-echo one tone, and one tone only. It will select, and respond to, and so reveal the presence of that tone, if it be in any combination of sounds. If it be not present, the resonator will be silent. Apply resonators to a noise, and they will show what notes are mingling in confusion in it, and that the components are pure and true and pleasant as music. Make a noise with a piano by striking its keys anyhow, and it is easy to see that each key struck makes a musical sound, and that it is their irregular mingling that makes the unpleasantnesses. Every simple sound is thus seen to be in all respects perfect. It is pleasant to the sense. It is in finest harmony with the perceptive power. Its wave vibrations, which strike the tympanum, are periodic. To and fro the particles oscillate, always passing the same point in the same interval. The order that is in all material particles, and in their sensibility to force, is thus beautifully exhibited. Their forms and characteristics, in their relationships to each other, are such that they are naturally fitted for executing perfect motions. Struck

irregularly, they cannot but move irregularly. Struck regularly, they move with a regularity that never fails. Were they a scene of disorder, harmonic motions would be impossible; the sounds produced would be confused and intolerable noises. But every simple sound, every note of music, proclaims the order which reigns in the particles by which it is conveyed. Every noise even, when it is analysed, bears the same testimony.

Periodic motions mingle harmoniously on the most magnificent scale. Single voices, as of the lark, the nightingale, and prima donna, are thrilling to hear. In a grand orchestra, accompanied by musical instruments, multitudinous motions mingle. They flow out in their hundreds of thousands in a second. They flow out soft and sweet, grand and beautiful. They mingle together. They follow each other in order, every motion in the place of harmony, every motion keeping rank, and faithful to an alliance of wondrous obligations. Rapid and multitudinous as they are, they throw not, in their haste, each other into confusion, they jostle not, they clash not, they produce not a hurricane of the irregular and intolerable, but a storm of the ordered and transporting. They are not as a crowd hastening wildly from the terrors of a building on fire, contending, struggling, trampling each other down. They are like an army marching over an extended plain, every man in his place, every footstep timed, their very feet having music in them. Their order is as perfect as that of atoms springing into combination, as those of light vibrations entering the eye. They enter the ear, crowded and packed though not as those of light, they enter it in an order magnificent to consider. A single and simple note, in which the motions follow each other at a measured distance of time and space, shows the fitness

of the conveying medium, the perfection with which it acts responsive to a measured stroke; but that great clusters of strokes should produce, every second, myriads of motions following each other with exquisite periodicity, forms a testimony to their condition of overmastering force.

Of the various media, consider the air. In a grand concert the motions fill a large hall to its every corner. Every particle in it is moving with exquisite grace, is responding to every touch and tone and change of tone; to the low, to the high, to the soft, to the grand, is playing its part as skilfully as the most practised of hands. Here as in light let genius do its best in producing music admired of all generations, let the Mendelssohns, the Mozarts, the Wagners, pour themselves forth each with his own *that*, his own brilliant characteristics; let the hand of genius, as of Stradivarius, make instruments, and also make them almost speak; let the kings and queens of song combine together and surpass themselves, the conveying medium will do justice to them. Have you gone out on a lovely spring morning, the sun shining as he alone can, and he only at morn or eventide; the young grass in its loveliest robe of green, and every blade of grass sparkling with nature's diamonds; have you gone forth and stood enthralled, listening to the song of the lark as it soared, to its outpouring of the most delicious notes, have you noticed that not far off and all round were others; have you walked or driven along a country road and found on every side the air thus occupied? Has imagination wandered to every valley and plain in all our land, and listened to myriads of sweet songsters, and at the same time seen the air filled with motions as perfect and as beautiful as the sounds that captivated the ear? And every country has its

song-birds, and the earth is girdled with music, and the perfection of the work of the air medium is revealed.

What shall we say also of the waters of the sea, occupied for miles with the motions of a bell, with those of the articulate sounds of a speaking-trumpet.

The trampling of men and horses, as we have seen, create near and far waves, which reach the ear, and produce in it the sensation of sound. The particles along the ground receive the motions with a sensibility that never fails, and send them forward with a faithfulness that knows not how to come short. The very characteristics of the sounding body they transmit. The peculiar features distinguishing it, and revealing its nature, they accurately convey. The motions are invisible. The eye cannot detect them. They send no messengers to it. To it the ground is at rest and is still. To the feet and the hands, or any part of the sense of touch, they exist not. But to the ear they are abundantly evident. It has power to take them in. It has the sensibility which enables it to receive and convey them to the brain, from which they pass to the perceiving nature, and to it they are transformed into sounds. The particles of the ground are so constituted, and possess a freedom of action among themselves, which enable them to respond to the tramp of men and horses, and not to them only but to the music of the drum, the pipe, the many instruments of the band, and to execute, over a wide extent, harmonic motions thrilling to consider. The whole ground is by such means thrown in its every particle into activity, in which condensations and rarefactions are being executed with a regularity which defies description.

What to appearance is more difficult to move than the particles which make up bricks and stones. They seem

at the greatest distance from any kind of motion among themselves. And yet, who has not heard through a gable wall the finest music, proving that the particles through and through were executing harmonic motions. There is not a wall in this city the particles of which its bells do not largely stir. When they are ringing even granite stones are moved. They are charmed. Their particles on the largest scale dart to and fro, execute motions corresponding to those in the metal. They beat also on the stones of the street. They spread out afar through the air. The imagination exults in the multitude and range of particles executing the same motions. They make to the mind endeavouring to realise them a scene of brilliant order and beauty. It is impossible, as the clang bursts over the city, as the chimes fall in sweetness on the ear, as the musical notes of psalm or hymn flow out,—it is impossible to listen without acknowledging the splendour of the music, the delight which it carries in its wings. It is as impossible to survey in imagination the motions of the sea of particles, numerous as the stars of the universe many times multiplied, without being as much lost in wonder and delight in presence of a splendour of order as beautiful to the mind as is the music to the ear.

The waves of sound behave as those of light. They are reflected and refracted. Speaking in face of a wall, the waves rush forward, reach it, and are instantly sent back again. To this is due the resonance in churches and halls when empty. Echoes are thus produced. Distinct and clearly articulated words are sent back from considerable distances. Calling at one point in the King's Park, Edinburgh, towards Morningside, the words are instantly sent back. There are such echoes in not a few places, and sometimes, between reflecting

surfaces, they are reflected again and again, and die away in sweetest cadences. Curved roofs reflect sounds, and sometimes concentrate them at points. Sound is also refracted even as light.

Velocity of sound.—Its velocity passing through any medium depends on the elasticity in relation to the density, and when these are known the velocity is easily determined, and always corresponds with the results obtained by experiment. Density depends on temperature, and therefore its increase or decrease affects the speed of transmission. In gases the velocity is least. In air at 0° Centigrade it is 1090 feet per second; at 5°, 1109; at 26·6°, 1140. The increase is very nearly 2 feet for every degree of temperature. The temperature may be deduced from the velocity of sound. So perfect is the observance of law in all material particles, so intimately are their various characteristics connected, that one may be employed to determine the other. All their properties and potencies are measured. The velocity in oxygen at 0° C. is 1040 feet per second; in hydrogen, 4164 feet; in carbonic oxide, 1107 feet; in carbon dioxide, 858 feet. Each gas has at the same temperature the same measured relationship of elasticity to density, and the same velocity with which it transmits sound. In liquids the velocity is greater than in gases. In river water, as in the Seine, at 15° C. it is 4174 feet per second; at 60° it is 5657. A salt dissolved in water increases its elasticity in relation to its density, and so makes the velocity greater. In a solution of common salt at 18° it is 5130; of chloride of calcium, 6493. In solids the elasticity in relation to the density is much greater than in liquids, and therefore the transmission of sound is much more rapid. In iron it is 16,822 feet per second; in copper, 11,666; in platinum, 8815; in silver,

8853. In fir, along the fibre, it is 15,218 feet; in oak, 12,622; in pine, 10,900. Thus in water the velocity is four times greater than in air; in pine ten times; in iron nearly seventeen times. If a long iron bar be struck, and an ear be applied to it at a distance, two sounds are heard, one along the iron and the other later through the air. Each substance has thus its own velocity with which it propagates sound. Between different substances the differences are great, but in the same substances in the same circumstances the samenesses are perfect. Air and every gas, water and whatsoever is liquid, iron and all metals, fir and wood of every fibre, each and all are true to their kind. So perfect is the accuracy that, given the velocity of sound, through any substance at a certain temperature, it would be possible to name it. So perfectly, according to temperature, throughout the whole realm of matter, are the elasticities and densities and their relationships determined. In all this we see the importance of elasticity as a property of matter, and of motions advancing by waves, and not by the advance of the substances. Air advancing at 800 miles an hour would be irresistible. But through the elasticity of material particles a mode of motion is obtained which advances with a high velocity, and yet with a gentleness imperceptible.

Sound is enfeebled by distance according to law. This is obvious to everyone endowed with the faculty of hearing. There is no loss of force generated, but it is evident that the volume of air acted on as the motions advance is constantly increasing, and therefore the force is divided among a greater number of particles. At any point the intensity varies inversely as the square of the distance.

The number of the waves.—Two instruments have been

invented for the purpose of numbering them. One is called Savart's wheel. In it there is a larger wheel driving a smaller, which is toothed. A piece of cardboard or strip of metal is so set as to touch the teeth as they go round. When the wheel is made to go slowly, clicks are heard. As the rapidity increases, the sounding rises to a continuous and harmonious blow. Knowing the number of teeth and of the revolutions in a second, the number of blows, and consequently of vibrations, is determined. In the siren a quick succession of puffs of air produces a musical sound. There is in it a wheel driving a circular disc, with holes at regular intervals, and a bellows which throws air on it as it rotates. As the rotation proceeds, the air is intercepted and passes through alternately, and when the motion is sufficiently rapid, and puffs sufficiently numerous, a note is produced. When an instrument or voice is sounding a note, it is only necessary to set one of these instruments in motion with a velocity which yields the same note in order to find the number of vibrations in it. In this manner the number of vibrations of certain insects' wings is found. In one case there are 12,000 in a second.

Tuning-forks yielding certain notes can thus have the number of their waves determined, as that they are 256, 320, 384, and 512 per second. The octave of every note is found by doubling the number of vibrations. A note of a hundred waves has for its first, second, third, fourth, and fifth octaves, 200, 400, 800, 1600, 3200. The lowest number, according to Helmholtz, which can make an impression on the human ear is 16; the highest 38,000. This represents a range of more than eleven octaves. The practical range is, however, from 40 to 4000, or seven octaves, thus equalling the number of colours. And as in the case of colours the sensations

are due to accurately numbered vibrations, so it is in the case of sounds. Begin where we please with any number of vibrations, by doubling them a musical and practised ear recognises the sound as the octave of the first. Thus, from 40, the lowest, to 4000, the highest, the sounds ascend, step by step, with a regularity which commands our admiration, even as the music which they make.

The length of the waves.—As the motion is uniform throughout, it is evident that the time required by any particle to execute a complete vibration is also the time in which a wave moves forward a distance equal to its own length. A particle rushes forward and a condensation is produced, it stops, it rushes backward to the point whence it came, and while it is doing so, the motion which it has created, advancing with the same velocity, darts forward the same distance as it does backward. In the time in which a complete oscillation is thus performed by the first particle, the motion has advanced by one wave length; when it has made two oscillations, by two wave lengths; when it has made 200 oscillations, by 200 wave lengths. When a tuning-fork vibrates 250 times in a second, it also in the same time forms 250 waves, and advances 1120 feet. The length of 250 waves is therefore 1120 feet, and so dividing, we get the length of one as 4 feet 5 inches. Three tuning-forks, vibrating 320, 384, and 512 times per second, create waves 3 feet 6 inches, 2 feet 11 inches, and 2 feet 2 inches in length. In hydrogen, waves of a certain length yield a note two octaves higher than if formed in air, because, in consequence of the velocity of advance, the ear receives four times the number of impulses. Each substance has its own measure of wave for each note, and always and everywhere for that substance in the same circumstances it is

the same, illustrating the exactness with which their elasticity and density have been determined and meted out to them.

Vibration of strings.—Pluck aside a string at its middle point, and the whole vibrates to and fro, yielding what is called its fundamental note. When a bridge is placed at the middle and either half is plucked aside, a note is produced which is the octave of the fundamental. A third part yields a note which is a fifth above the octave. Half the string creates twice as many vibrations as the whole; one-third three times as many; one-fourth four times the number. The law is that the number of vibrations is inversely proportional to the length of the string.

The number also depends on the tension of the string, or on the force by which it is stretched. For experiment a string is fixed at a point, passes at once over one bridge, and after an interval over another, then over a wheel which moves freely. It is then stretched by a weight. If the weight be a pound, and the vibrations so many, in order to double the number, or obtain the octave, it is necessary to stretch by a weight of four pounds; to treble the number, the weight must be nine pounds; to quadruple, it must be sixteen. If other things be equal, the number of vibrations is in proportion to the square roots of the stretching weights.

The thickness of the string also plays its part, produces its appropriate and measured effect. If two strings be alike in every respect except in thickness, and the diameter of the one be twice that of the other, the thinner string will create twice the number of vibrations of the thicker. If the diameter of the one be three or four or five times that of the other, the number of vibrations will be lessened three or four or five times, showing the law to be that it is inversely proportional to the thickness.

Hence there are thicker strings in instruments for the lower notes and thinner for the higher. The number of vibrations is also inversely proportional to the density of the strings. Combining these two, we have a law that the number of vibrations is inversely proportional to the square root of the weight of the strings.

Here, as everywhere, all is according to law, measures, and numbers. Strings of the same measures produce in the same kinds of particles the same number of oscillations. The particles aggregated and cohering in the strings execute their motions accurately, according to their length, tension, diameter, and density. The particles of every medium by which sound is carried respond with unfailing accuracy to measured causes, and yield sounds in harmony with those causes.

Musical instruments differ in the qualities of the notes they yield, in what has been called their timbre or clang-tint. This is due to overtones. A stretched string may be made to vibrate in whole or in parts. It is found impossible in practice to make it vibrate as a whole without also vibrating in parts. The higher notes, produced by the parts, are termed the harmonics of the string. It is the union of the harmonics with the fundamental note that gives to each instrument the peculiarities or tint that distinguishes it. If fundamental notes be separated from harmonics, from whatever source they come they cannot be recognised as different. It is therefore a very beautiful arrangement that sounding bodies should give birth to overtones in addition to those that are specially sought from them, and that there should thus be produced so great and pleasing a variety of clang-tint. It is an exquisite result that the overtones should all be harmonics of the fundamental, should be of such a nature as to blend with it, and with each other, to form one perfectly

beautiful and characteristic sound. In all music the overtones are evidently more numerous than the fundamental, and if they had been out of harmony with it and with each other, the effect would have been disastrous. A musical string, a musical instrument, could not have been made. That none such appear is due to the perfect order that reigns in nature, to the perfect adjustment of its particles in aggregation for harmonic action.

The vibrations of rods.—When they are fixed at both ends, the laws of their action are, in some respects, the same as in strings. Those of vibrating parts, when divisions are made by damping, are different on account of the different forces brought into play, namely, the elasticity of the rod itself, and not external causes of tension. The number of vibrations, when the whole rod oscillates, and when there are two or three divisions, are as 9 to 25, to 49, to 81, or as the squares of the uneven numbers. Reasons might be assigned why the proportions should be as the squares, but the facts are very striking.

The vibrations of a rod, fixed at one end and free at the other, are also produced through the elasticity of its substance. The number of vibrations in a unit of time is inversely proportional to the square of the length of the rod. If a rod 36 inches long vibrate once in a second, one 12 inches long will vibrate nine times, one 6 inches long thirty-six times, one 3 inches 144 times, one a single inch 1296 times. Plates and bells follow the same laws. The celebrated Chladin first employed fine sand sprinkled on plates to show to the eye the motions in them when vibrating. A square plate of metal is fixed at its centre. The middle of one of the sides is damped by the touch of the finger nail, and a violin bow is drawn across near to one of the corners. The sand is at once set in motion, and arranges itself in lines from side to side

through the centre at right angles to each other. This division of the plate corresponds to the deepest tone. Again sprinkling sand over the surface, and damping one of the corners, and drawing a bow across the centre of one of the sides, the experimenter sees the sand dancing over the plate, and finally arranging itself along the diagonals. The note produced is the fifth above the fundamental. If two points be damped on one side, and a bow be drawn across that opposite to it, a much shriller note is heard, diagonal lines are formed, and the two nodes are joined by a curve. By various dampings a great many beautiful figures are drawn by the sand. Round plates also exhibit regular motions. One is set horizontally on a stand, blackened in colour, and fine white sand scattered over it. If its edge be damped at any point, and a bow be drawn across 45° distant, it yields its fundamental note, and the sand arranges itself along two diameters. If the bow be drawn across at the distance of 30° from the point damped, the sand takes the form of a star, in which there are six nodal lines, forming six segments. In some way the plate may be divided into 8, 10, 12, 14, 16 segments. The number is always even. As the divisions are multiplied, the vibrations become more numerous, and the note is raised in pitch. That given forth by sixteen sectors is painful in its sharpness.

Bells exhibit the phenomena of vibrating discs, and if one be filled with water, and struck, music wavelets are formed.

Sound vibrations are also created in a longitudinal direction—in strings, rods, plates, and bells. They are produced by a bow drawn obliquely over a string, or by means of cloth or leather powdered with resin, and drawn sharply along. An iron wire is attached to a sounding board, and drawn tight at the other end.

When resined cloth is moved to and fro along it, a musical note is heard much higher than if it were plucked aside. If the wire be divided into two halves, the number of vibrations is doubled, and the octave of the first note is heard. If a third of it be taken, it yields the fifth above the octave; if a fourth, the second octave. In longitudinal vibrations, as in transversal, the number is proportional to the length of the wire. It is not the wire that gives forth the sound, but the sounding board. The vibrations created by it are at right angles to those in the wire, and so are transversal. In it the particles of the iron are set in rapid motion, to and fro, in the direction of the length, and in that direction are harmonic, are exceedingly rapid, and so yield a high-pitched note.

An iron rod and a brass will yield the same note if their lengths be in proportion to the velocity of sound in them, *i.e.* as 11 to 17.

Notes are also produced in rods of wood by rubbing with resined leather, and they follow the same laws.

Harmonic motions are produced in rods free at both ends. A glass tube is held at the centre, and one end vigorously rubbed, when a musical note is emitted. Longitudinal vibrations are created from end to end of the rod, and at the further end pieces fall off in rings.

Resonance.—A tuning-fork vibrating, say, 256 times in a second, placed over a glass jar, may yield little or no sound. Pour water into the jar, the sound increases, till reaching a certain height it bursts forth loudly. On measuring the depth to the water, it is found to be 13 inches, or one-fourth the length of the sonorous wave of such a fork. The motions from the prong, and those reflected from the water, are timed for each other, and so unite, and the note becomes loud and clear. Every tuning-fork has its own depth of jar, which

causes resonance. From this it is evident that resonators may be made which shall be responsive to only one note in the scale, and thus may be employed to discover if that note be present in any sound. It is by means of resonators that the difference in clang-tint in musical instruments is found to be due to overtones.

As in their chemical activities and the motions they produce in light, so in their action in yielding sound, the ordered condition of material elements is revealed. The particles, urged on by the force of elasticity, execute motions that vie in regularity with those seen in any other field.

The measures of elasticity, found in nature, are collocated at points and within ranges such that they produce motions which fit into the range of the perceiving organ. Had they been rapid as those of light, they would have been imperceptible. In that science we dealt with hundreds of billions. Light motions begin at about 400 billions and end at towards 800. Those of sound begin, practically, at 40 per second, and end at 4000, although fewer and nearly ten times larger numbers may be heard. Thus between the ranges of the numbers of motions in sound and light the difference is very great, but both are suitable, each for the organ to which it ministers.

The ear forms a delicate test of the regularity of the action of the particles. The least disorder produces noises. And it abhors and is pained by them. There are noises that are terrible to hear. But these are not due to nature's work, to the originating cause in its particles, nor to those of the conveying medium. Their honour has been saved by the discovery that noises are composed of pleasant sounds, irregularly mingled, irregularly caused. Let a cause work regularly and the sound

will be pleasant. The ordered originating cause and the conveying medium work unto perfection. They respond to the highest skill. They satisfy the finest ear. There are those that have a genius for music, that have perceptive power of exquisite sensibility. They may often be pained by performers, and discover noises in their work, but they never dream of blaming nature's elements. They know that they respond to their own finest work, and fail them never.

We have spoken of particles because sound motions are borne forward, not strictly by the molecules and atoms; but in the last resort their properties determine all, for were they not ordered the particles could do nothing.

VII

LIFE—PROTOPLASM

Protoplasm — Its First Appearance — Complex Construction — Environment—Evolution from Elements—Haeckel's Carbon Theory—Special Life Element.

LIFE is of profoundest interest. It is an element having a charm all its own. It enters into, and on it depends, the formation of organic structures, in which are riches of order. It appears in a protoplasmic unit, in the lowly moss, in grass of the field, in flowers of the garden, in the noble oak and fruitful vine. It rises higher in riches and power in the fowls of the air, fish of the sea, and beasts of the field. It flows in majesty in man. In him it receives its loftiest consecration, rises into its highest field of action.

We are met at the threshold by the question, What is life? What is its nature? In what does it consist? Does it result from a peculiar combination of atoms built up into a complex structure? Or is it some form of immaterial entity, having relations to and consequently power over matter, to control and direct its action? We do not propose to discuss these questions, but to show that the known elements entering into its production reveal in their action the clearest signs that they are the work of a great understanding, and that the special entity, if such there be, proceeds from the same exalted source. The simplest form of life is protoplasm, which,

Haeckel says, is "a connected chain of material phenomena, of atoms placed together in a most varied manner." Professor Huxley affirmed that a mass of living protoplasm is simply a molecular machine of great complexity, the total results of the working of which, or its vital phenomena, depend on the one hand on its constitution, and on the other on the energy supplied to it. They maintain that, although abiogenesis be now unknown, protoplasm must have come into existence through the action of natural causes going before. Let us admit their contention and consider the consequences to which it leads. Protoplasm, suppose, has in it only material elements, and was formed in the order of nature in a suitable environment. Making these admissions, we yet maintain that it is wholly the work of mind—(1) in its origin, (2) in its constitution, (3) in the environment in which it was formed, and (4) in the elements entering into it.

(1) *In its origin.*—The first protoplasm was a momentous advance. Its coming into being was fraught with consequences the grandest. What were the world without life? What was it before the vital spark appeared? It was a wilderness blank and lone. And when the first protoplasm sprang into being with the dew of youth upon it and inexhaustible possibilities stored in it, well might the morning stars sing together and the sons of God shout for joy. It was the beginning of a new era, the dawn of a new and glorious day. It was the appearance on the scene of a worker, still and lowly, but of transcendent power. Was, then, the coming into being of so potent a nature a mere contingency? Was it an infinitely happy chance? Did the good fortune of the earth, which along with the universe in general seems (if so we can believe) to have known the most marvellous good fortune in its countless evolutions, serve it with

special zeal in this most potent birth? Did the world of life, that has advanced so far and in directions so varied, that has climbed so high and broken forth in organisations so dazzling,—did this world of life hang in the beginning on a gossamer thread? Is that first protoplasm, which has marched steadily forward, producing at every stage designs without number, and having in them myriads of complex arrangements that seem the devising of a God,—is that first protoplasm itself the work of chance and haphazard? It is not, and it cannot be. The human mind indignantly rebels against all doctrines of the evolution of the ordered kosmos, of the evolution of a single speck of protoplasm, save as the result of the working of intelligence.

(2) *In its constitution.*—Protoplasm is a great art structure. A globule of it is a machine which man cannot make, which all his genius cannot put together. It is a building which no human skill can raise, the stones of which no hand can set in their places. The atoms and molecules in it are many. Its stones are numerous as those in royal palaces. Its parts are more in number than in complex machines. They are minute with a minuteness which defies all means of perception. They are collocated and joined together in a most varied manner and with exquisite precision. There are molecular motions, heat and life motions, without number. A unit is thus formed, a speck of protoplasm put together and built up, and life generated. It is an exquisite building, an exquisite machine, in which are a thousand measurings and joinings together, in which, at every minutest point, the work is the finest, the adjustments the nicest, the measurings and joinings the most perfect. It is a gem of architecture, a machine showing invention in its glory. It is the arrangement of a system of worlds

in an infinitesimal worldkin. A palace of like genius would make its architect immortal. A machine as complex and perfect would invest its inventor with undying fame.

And the life in it vies with it in wonderfulness. The building is an art triumph, and its inhabitant is royal in interest and dignity. The machine is a gem of invention, and the fire of the choicest of the world's jewels pales and disappears before the glory flaming at its heart. And this building Huxley and Haeckel affirm gives birth to its inhabitant. The building produces as the result of its matchless form its still more matchless indweller occupying it. Its construction is an everlasting marvel, and it is a marvel still greater in the life which it makes to beat and throb within its chambers and galleries. How then did this protoplasmic wonder spring into being? To what are due combinations, measurings, so many, so exquisite and fruitful? To what but to a mind of power equal to work so transcendent. The understanding must deny itself that refuses to see a Worker so brilliantly revealed.

(3) *In the environment.*—The environment must have been one, as far as can be seen, available under the present conditions of the world. While the earth was aglow with heat, where the ice king reigned with deadly severity, life could not be generated. And as the environment cannot now be found, cannot now be formed, though much the same circumstances must exist, its formation, on the principles of Haeckel, must have been an event of unparalleled good fortune, the very accident of accidents. It must also have been of a very special nature, as special as protoplasm itself, which now alone can accomplish the work. It must have been as marvellously ordered, and its properties measured and adapted for producing the

necessary combinations and collocations, for compelling the molecules to spring into the multitude of places which it is necessary for them to take, and so to build up a machine of such nicety and multiplicity of parts. And so the environment was a work of mind. The environment can only thus be accounted for. And every element entering into it and forming it is richly ordered, and must be ascribed to the same source.

If protoplasm came into being in a peculiar environment, it might have been (1) that only in that environment it would have been possible for it to persist; and (2) that it only should have been able to multiply in it, and that it should not have been capable of multiplying itself in a multitude of environments.

(4) *In the elements.*—Protoplasm, in its origin, even if it came into existence as the fruit of operations going before, is radiant with signs of mind. It is built up with a brilliancy of constructive power unapproachable by man. It yields the lofty element of life. The environment necessary to its evolution and multiplication, to its processes and advances, was also rich in the results of intelligent working. The elements, therefore, rising to so great a height, yielding a form of being which has produced the whole living world, afford proofs of the most convincing force from whence they have come. The difficulty of building up the protoplasmic structure cannot be exaggerated, and it is impossible to make too much of it as an evidence of the many ordered qualities of the substances which perform the work. The vitality of the structure is of high rank, and that the atoms should be capable by evolution and organisation of striking out a spark so exalted and so permanent, evinces most clearly that for it they have been specially endowed.

Protoplasmic globules are more wonderful than atoms,

molecules, and chemical compounds. All atoms existing are measured, weighed, and shaped, and make easily manifest the hand that made them. Chemical compounds without number show a world of the most accurate measuring of the atoms for each other, of the most perfect adjustment of element to element. They also develop qualities unknown to the elements entering into them. But these results are surpassed by those of protoplasm. Its life is a development which stands far in front of and above the most remarkable results of chemical combination. These results can be classed together. They are of the same kind. They belong to the same realm. But life cannot be classed with them. It is not of their, it is of another kind. It does not belong to their realm. It forms a kingdom of a new and higher order. It has characteristics and powers which brilliantly distinguish it and exalt it to a plane of its own in the world of being. Glorious as are the elements of matter, wonderfully measured also and adjusted in order to form chemical combinations with properties so varied, they yet have no glory in these operations, by reason of the glory that excelleth. In producing the simplest living forms they surpass themselves, they take wings, they soar to the loftiest heights. A speck of protoplasm is a new triumph of their working, is a new revelation of what they can do, of the riches of order and potency that characterise them. It makes manifest their possession of endowments so peculiar and so high as to add in an inexpressible measure to the force of the argument derived from the chemical field showing whence they come.

The essential substances forming protoplasm are carbon, oxygen, hydrogen, and nitrogen. The atoms of these elements do not show any signs of life. Their ordinary

compounds do not show any. They are found only in protoplasm, into the composition of which all the four kinds of atoms enter. Each element must, it is evident, contribute something to the production of the result attained, and the result must depend on its containing that something. If carbon had been wanting in what forms its contribution, if hydrogen had been lacking in its quota, if oxygen and nitrogen had been unequal to the demands made on them; if every atom of these elements had not been distinguished by its own special characteristic contributory to the building up of the protoplasmic substance, life would not have been. A multitude of conditions must be fulfilled in order that the simplest living forms may be brought into existence. It is a pure contingency that two atoms of carbon should possess the necessary characteristics. It is a pure contingency that two atoms of oxygen, hydrogen, and nitrogen should. The contingencies go far beyond all numbers that every atom of each kind existing in the universe should. In producing results so peculiar out of entities so vast in number, who can believe that chance had any part, who can believe that it could have yielded atoms for the least living globule? Have we not here irresistible evidence that, if this view of the origin of life be true, these elements of matter have been made and adapted for their place and work?

Nothing can be more irrational than to affirm of these workers and their workings, that they simply say to us: "We are as you see, and there is nothing and no one beside us or behind us. We are workers. We are matchless in form and endowment. We are adapted and adjusted to each other. We form combinations. We conduct processes. We build up structures. We kindle life's spark. We are fitted for the work, and we do it,

and can say no more. We have no further revelation to make. We have no message from any world unseen. We have no light from a higher sphere. We exist, and we operate after our fashion, and that is all." But it is not all. They do not thus speak. They are thus made as if they were a chaos, as if they were on a level with particles of different measures, characteristics, and forces, and having no relationship to, and adaptation for, each other, but fit only to exist in space, loose, useless, and inert incapability itself. The latter would have no message. They could only say: "We exist. We exist each particle by itself and for itself. We know not each other. We are nothing to each other. We cannot draw together. We can neither combine nor build. It is not in us to produce the pitifullest infinitesimal fraction of a product. We are helpless, meaningless, messageless." But it is not so with the former. They are not a chaos. They are not loose, unrelated, and incapable. They are rich in potencies and relationships, and can build up and produce upon the most magnificent scale and with the most brilliant results. And therefore they are not to be degraded to the level of the latter, as if they spake the same empty speech. They are not as they, helpless and useless, and therefore are not meaningless and messageless. They mean largely. They are charged with the grandest of messages. They shine with a light whose source cannot be mistaken, a light which can only proceed from mind, and which only mind can interpret, but whose meaning the simplest intelligence can easily recognise. They speak with a clearness and force to cure deafness. They do not cry out and shout and roar as the hurricane, the earthquake, and the fire. They speak in a still small voice, but in tones so distinct and so divine, as to make him who hath a hearing ear wrap his face in a mantle.

They say: "A divine mind is in all our work, and on our every atom. The Only Wise made us, and clothed us with ordered potencies and adjusted relationships, and all our fitnesses for the work we do, the structures we build up, and the life we yield. We are His servants, the work of His hand."

Haeckel puts forward what he calls his great carbon theory of life. He ascribes to this substance the chief potencies by which life is generated and the organisations of the world built up. Carbon he supposes to be so marvellously endowed as to be capable of quickening, moulding, and fashioning all things that are quickened, moulded, and fashioned. Carbon is the true fountain of vitality, and does all things that have been ascribed to a wonder-working God. Carbon is God. But if carbon be God there are gods many indeed. One atom of carbon would be impotent. It could accomplish nothing. It depends on the existence of another, and another, and others innumerable. It depends on finding them like itself, characterised by its own properties, possessing its own high endowments, by which it can work its wonders. It also depends on its finding materials with which to build, on its finding side by side with it, in its sphere and within range of its influence, atoms of oxygen, hydrogen, and nitrogen. Innumerable carbon atoms must exist, innumerable master-builders, and these must find the vastest quantities of three other substances, the vastest multitudes of individual atoms, and all and every one so measured and adjusted to themselves in many minutest respects, that they can lay hold of them, mould, and fashion, and build them up into complex forms, and in these give birth to life and its marvels. The amount of dependence of carbon in this work ascribed to it is enormous. Instead of being an entity absolutely in-

dependent and clothed with power capable of the greatest things, it is rather infinitely dependent, dependent on chances to which there is no number. Carbon cannot account for the world of life. Carbon must itself be accounted for. In like manner it is evident that hydrogen cannot account for it, that oxygen cannot, nitrogen cannot. To yield the earth and its life demands the existence of all these elements in multitudes so multitudinous and ordered that we are compelled to look outside themselves for the wisdom and power that have fitted them for their work.

This theory brings into strongest relief the force of the arguments for the creation of the elements. It shows the riches of order and potency that must be in carbon in order to its being equal to the accomplishment of tasks so high. It is compelled to speak of carbon as if it were a unity, intelligent and powerful, and therefore could easily act as one, do brilliant work in the sphere of mind, and produce gems of organisation, as if it could easily seek and find and bring other substances into its service, and employ them to build up unities of the most complex nature. But carbon is not a unity. It is made up of particles the smallest, of numbers the vastest. And many cannot of themselves act as one unless there be concert among them, and intelligence to produce the concert. The most extravagant imagination cannot ascribe high intelligence to carbon atoms, cannot dream of affirming that they take counsel together to produce harmonious action. Neither is there in their midst king, or queen, or leader, or commander, or guide. And yet the shout of a king is among them, the sound of the goings of a king of kings in the realm of mind is in their operations. In their vast multitudes they are as if perfectly led, commanded, and guided. They move and

march as if to music. They spring into their own places with unfailing accuracy, find and lay hold of their related molecules, and moulding and fashioning them according to their will, build up structures the most complex and beating with the pulses of life. The unity of action and greatness of mind revealed in their action is exceeding wonderful. And not being in and of themselves, it must be on and from outside of them. The atoms must be made by mind for their work. They are formed and measured in their every characteristic with matchless accuracy. The samenesses in them are of extraordinary fineness and richness. The potencies enabling them to build up and put together the many parts of the protoplasmic machine are marvellous in the highest degree, and must have in them balancings of forces and adjustments to the other kinds of molecules of the most exquisite nature. The potencies that enable them in the protoplasmic forms to give birth to the springs of life place them far in front of and above other atoms, make them the chiefest glory of a transcendently glorious universe. The collocation therefore in centres so small, in numbers so vast, of the same measured powers, so peculiar and so high, forms an evidence of the presence and action of mind of overwhelming force. Atoms having in them not only the power of combining with other atoms, but also the amazing properties that enable them to build up protoplasmic structures, and originate in them the throbbings of vitality, cannot but have their existence due to one glorious mind, who knew what was being produced in each atom, who understood the great and ordered work required of it, and what was necessary to be put into it, in order that it might be equal to its performance.

It follows that its colleague elements were made for it.

If the contention on behalf of carbon be true, if it be endowed with the characteristics to which is due the kindling of life's spark, yet is it helpless standing alone. It can do nothing without hydrogen, oxygen, and nitrogen. These must also be specially endowed for the high qualities with which carbon is favoured, in order that they may be able to call them forth. Chlorine cannot take the place of hydrogen, iodine cannot act for oxygen, phosphorus cannot play the part of nitrogen; neither can one of the three be substituted for any of its fellows. Hydrogen, and hydrogen alone, but its every atom, has properties able to render to royal carbon the aid required at its hand. Oxygen and nitrogen, and they only, but every atom of each existing, can minister help to the divine element after their fashion; and all three are needed. Oxygen by itself, however willing and ready for fervours, could not have rescued the qualities of its exalted superior from lying eternally dormant. Hydrogen could not, nitrogen could not; no two by their utmost efforts could have advanced it more than a step in the direction of its goal. All three must put forth their strength in many ways, in order that the springs of life may be opened. It was impossible that by chance there should be so great a number of carbon atoms found by each other, endowed according to the demands made on them by this theory. It was impossible that, by chance, carbon should have found as many atoms of one element, if that had been sufficient for it, measured and adapted for its requirements, as would have made a single living globule; but what shall we say of the impossibility of multitudinous atoms of carbon finding multitudes without number, not of one element only and its contributions in aid, but of three, and each atom of them so endowed that, after forming combinations and organisations, it should be

enabled to rise to the heights of vital activity. Is it not clear, therefore, that oxygen, hydrogen, and nitrogen have been made, and their properties adapted for those of carbon?

On the other hand, if the life-yielding potencies be divided among two or three, or equally among the four, elements, and all have equally important parts to play, the division among the greater number of elements or kinds of atoms, the distribution among them of exactly the same amount of potency, or proportion, or kind of potency, required a nicety of discrimination only to be found in an understanding and perceiving nature of inconceivable power, required a greater intelligence than even the concentration of them in one of the kinds.

A certain temperature is also necessary to the existence of life. There are forms which can sustain very low temperatures, which can bear the cold of the Arctic regions; there are algæ which have been found in hot springs of a high temperature. Life is for the most part possible within very narrow limits of heat and cold. Heat in the molecules is a form of motion. Had there been no such motions, life would not have been; had the motions been all and always beyond a certain number—and they might have been far beyond it—life would have been impossible. Its existence on the earth, therefore, depends on the number of heat motions being executed by the molecules of matter. These must not go above a certain amount; they must not go below a certain amount. The limits are comparatively narrow; their heat depends on their relationship to the ether, on the energy they receive from it, and through it from the sun. It is not enough, in order to obtain the least globule of protoplasm, to have a sufficiency of atoms specially ordered for its formation. There must be sufficient to

form the sun also. And as necessary is the ether, as necessary are its properties, and measures, and forms of action, and adjustments. We have thus a fifth element introduced, differing widely from carbon, oxygen, hydrogen, and nitrogen, and yet accurately measured for them, and adjusted to them, in such a way and measure of action, as to come to their aid and enable them to build, beat, and live. These molecules were therefore made for the ether, and the ether for the molecules. Thus, if we take into account the contingencies in the four chemical elements, in their possessing characteristics fitting them for being built into the combinations and complexities of the structure, that yield protoplasmic life, the necessity that it and all matter connected with it should have a certain number of heat motions, and not go beyond a certain number, that there should be an ether, differing widely from molecules, and yet adjusted to them, so as to convey heat motions from the sun,—in these things we surely have facts that ought not to be capable of being misunderstood.

If a life element be postulated, if, in addition to the molecules and ether, another entity of a higher nature exist, the multitude of contingencies is not diminished, the evidence for the operation of mind loses nothing of its force. In this case every atom of the four elements is not only measured and adjusted to every other atom and to the ether, but to an additional vital element; and the vital element is measured and adjusted to them, so as to be capable of taking hold of them and building them up into a complex life structure. The vital element is in its nature far apart from the atoms and ether. Its properties are peculiarly its own. Its specialties and modes of operation are strikingly singular. And yet in its every characteristic it is measured for action on the

compounds of four material elements in their every molecule; and for association with the action of the ether at every point, it is measured for building up the elements into the complex life structure, and they show themselves prepared to enter its service and obey its every behest. It is evident, therefore, that by the introduction of an additional entity, the force of the argument for molecules and ether and vital element being made by intelligence remains in the fulness of its force.

VIII

CELLS AND ORGANISATIONS

Cells — Their Construction, Multiplication, and Modification — Egg-Cells—The Building up of Animal Forms—Greatness of the Work—Mind in it—Wealth of Order in the Cells.

THE simplest living forms consist of globules of protoplasm. The next in the ascending scale are cells. They are made of an outer substance, in a state between the fluid and the solid, and an inner called the nucleus, which is more solid than the first. Both are albuminous in their nature. They are the two essentials in the constitution of cells. They take in fatty particles, crystals, colouring matter, and various substances; but these are not necessary to their peculiar powers of action. The cells of plants have, besides, generally a membrane as a wall enclosing them.

When the various parts of plants and animals are examined, they are found to consist of cells. The grass of the field, the leaves of the forest, the flowers of the garden, and the fruits of the orchard are built of cells. The flesh and blood and bones of animals are composed of the same elemental forms. Nerve cells are specially complex in their nature. The ganglion cells of the brain surpass in complexity, and are magnificent adaptations for their work.

There are many one-celled organisms, as the amœbæ, desmids, diatoms, etc. They are found principally in

fresh water, but also in the sea, and even in moist earth. Some have the power of pushing out the protoplasm at any point in finger-like processes, and by means of these they move about. Sometimes they are a mere round ball, while at others they are surrounded by processes which they have thrust out. In certain circumstances, if there be impurity in the water, they become encased in a protecting membrane. At any point in their body they can take in food, and so increase and grow. By and by they separate gradually into two halves; these again feed, increase, divide, and so the multiplication goes on. In amœbæ and kindred forms, we thus have single cells enjoying and performing the functions of animal life.

(1) *Cells consist of protoplasm with a nucleus.*—In them the centre is differentiated from the circumference. The outer substance is a machine of great complexity, built up in one way. The nucleus is a machine of great complexity, built up in a somewhat different way. Each cell is formed of myriads of particles; there are in each innumerable adjustments, balancings, and joinings together. In the process of evolution, the molecules reached first one form, and then marched forward to another and double form. Having made one successful advance, they hastened to make it still more successful. Having gained the triumph of producing a structure in which a tiny life-spring appeared on the field of existence, as if knowing the promise laid up in a beginning so wonderful and the loftiness of the heights that might from it be reached, they proceeded to the production of an advanced structure on the straight line leading to those heights; they proceeded to the making of protoplasm into stones capable of being built into organisations, in which life might flow in rivers and streams. Single

atoms impress us; combinations are an admiration; but protoplasmic cells bear the palm. Mansions of gold, adorned with rubies and diamonds and all precious stones, would be a sight to see. Aggregations of gold molecules are a splendour, ruby and diamond crystals are altogether lovely, but they are so to the eye of sense. Cells of which the mansions and temples of life are built up are splendours and lovelinesses to the eye of the mind; each stone is as if centuries of thought had been concentrated on its plan, as if centuries of care had been spent on its construction, as if divinest skill and the finest hand had laboured with enthusiasm in its production, had triumphed in bringing it to perfection. Ruskin says of Michael Angelo, that he put into every bit of stone he touched that which makes the hair stand up and words be few. How much more may we say, that in a cell is that which, in him who sees, makes the hair stand up and words die away! No words can do justice to it. Dare anyone, then, affirm that thought never touched it, that skilled finger never approached it? It was so fortunate an advance. So much depended on it. It was so fruitful. It prepared for flights so lofty. It was so necessary. Without it the origination of life would have been comparatively in vain. It was too fortunate, too fruitful, too necessary to be due to anything but a wondrous intelligence advancing steadily towards, and making it the preparation for, reaching a glorious goal. Atoms and molecules also, capable of being developed into it, required to be too richly ordered and endowed to have their existence ascribed to any but the same cause.

(2) *Cells multiply their kind.*—The protoplasm draws in suitable materials and grows. The nucleus demands of it its portion. After a certain amount of growth division takes place. In this manner cells are being produced

with ease and profusion over the fields and mountains of the earth, and in the depths of the sea. Building is going on incessantly. Molecular life machines are ever forming. Webs of them are constantly weaving. Their power of work is superb; they know no weariness, no hardness in their toil, no need of rest. Their genius for building is supreme. Laying hold of all suitable materials, they throw them into their own form. They collocate them. They make them stand in right relations. Every molecule is obedient to their call; every molecule at their touch springs into the position required of it, and in that position performs the functions thereof. The places are many; the molecules and functions many. The work is great, its nicety exquisite. Its difficulty in itself is enormous. In short, all the operations are skilled in the highest degree, and yet are performed as by a master hand. The invention of cells was a triumph of thought. The invention of a machine to make them would have been, if possible, a still greater triumph. But it is the ideal of invention, that they are so constituted as to be themselves capable of producing their kind. Every cell made becomes also a maker. It can not only fill its own place in an organisation and do its own work, it can provide for another place an instrument for its work. There are in it arrangements which, though no doubt simple, must yet be most ingenious, by which at every point it is enabled to receive suitable materials, and bring them into its own form; and so that, when suitably increased, forces are called into play through which a division takes place, which leaves two as perfect as was the one.

(3) *Cells are capable of innumerable modifications and variations.*—There is one cell for grass, another for trees, another for fruits. There is one for the flesh of beasts,

another for that of birds, and another for that of fishes. There is its own variation for every kind of grass or tree. There is its special modification for every part of the animal frame, for flesh and blood, for bones and nerves. In all things that grow out of the ground, and in every creature that liveth, in all flora and fauna, the modifications are countless. The variability is thus most extensive. Its existence is also of supreme importance, for upon it depends the variety in the living world. In the presence of so vast a multitude of variations, of so wonderful a capacity for yielding differentiations, while persistently retaining the same general form, we cannot but be filled with a great admiration. If the matter had depended on chance, there might not have been a single variability. The least touch of variation, the feeblest cause tending to produce it in cells having in them adjustments so fine, might have destroyed the essential form. The stability of the first form evolved might have been such, that the least interference would have broken it up. Every additional variability is therefore a new contingency. And the number of contingencies that the cells should be capable of variability so extensive is inexpressible.

If then it be maintained that nothing but matter hath being in the world, that nothing but molecules and their properties have part in vital operations, we have in cells a multitude of contingencies as, that these should be able to combine and form a structure so extraordinary as to yield life, that they should have it in them to form the nucleus, the ganglion cells of the brain, and the amœbæ. It is a natural and eternal impossibility that chance should have given the multitude of atoms necessary for development into cells so numerous and so magnificent. And when we add to this the power which they have of feed-

ing, and dividing, and multiplying their kind, we introduce additional contingencies. There might have been cells formed without the power of feeding and growing. They might have fed, and swelled, and remained one, or burst into useless fragments. In the midst of countless possibilities, it is very wonderful that the atoms should be so constituted, and the forces in the molecules so balanced, as in all respects to be favourable for producing the results that lead to consequences of the grandest nature.

Egg-cells.—In these we have a third advance and the greatest. In them the molecules have shown that they have in them the power of crowning their triumphant march, of producing organisations of the greatest complexity. Ordinary cells are builders, these are architects and master-builders. Ordinary cells are soldiers, these are generals, raising and marshalling armies. Other cells are individuals, doing what lieth to their hand. These are kings, producing, varying, giving law to and determining the operations of the millions of their children. They consist of protoplasm and a nucleus. The protoplasm is called the yelk, the nucleus, the germinal vesicle. These are the essential parts. In animals the egg of the female generally grows by the addition of protoplasm, or egg yelk, and is surrounded by a protecting membrane, and in birds by a calcareous shell. It is one of the largest cells, not being really one cell. The male sperm cell, on the other hand, is one of the smallest. It has an exceedingly small body, with an oblong nucleus and a comparatively long vibrating filament attached to it. It is characterised by a very peculiar quick movement called the spermatozoic movement.

Sperm ovules and egg-cells unite and form a parent

cell. It feeds and grows, divides and multiplies, into 2, into 4, into 8, 16, 32, 64, 128, 256, or as in mammalia and amphibian eggs, into 2, 4, 8, 12, 16, 24, 32, 48, 64, 96, 160. A globular mass of cells is constructed called the mulberry germ. By and by there is an inversion of the cells. At one point they begin to sink, and a cup is formed. At the same time the inner ones become rounder, the outer longer—the latter also smaller and more numerous and darker. The protoplasm of the cells differs. Chemical, physical, and morphological changes are produced, and thus differentiation, which plays so important a part, begins. This is the process in the lower animal forms. In the higher the processes are somewhat different, but in all different layers of cells are produced, distinguished by different characteristics. The two germ layers next multiply into four, which assume the shape of a tube. They are called the skin sensory layer, the skin fibrous, the intestinal fibrous, the intestinal glandular. According to Haeckel—I. The skin sensory layer produces (1) the outer skin, and in the higher vertebrates the hair, nails, and the sweat and sebaceous glands; (2) the central nerve system, and the medullary or spinal canal. During the development of the individual, it moves gradually inward, so that at length it is situated internally, surrounded by muscles and bones and other parts. The primitive kidney is also probably from it. It eventually takes a deeper place within the body. II. The second, or skin fibrous layer, yields (1) the leather skin, the firm fibrous covering which contains the nerves and blood-vessels of the skin; (2) the great masses of the muscles of the whole trunk; (3) the inner skeleton, which is specially characteristic of vertebrates, the articulated vertebral column, also all the bones, cartilages, and ligaments, which form the vertebral

skeleton; (4) the cell layer, which forms the inner covering of the body wall. III. The third or intestinal fibrous layer develops (1) the endocœlar, or layer of cells covering the outer surface of the whole intestine; (2) the heart and the great blood-vessels of the body, the great blood channels or arteries going from the heart, the great veins passing to the heart as well as the blood itself; (3) the muscular tube of the intestines, *i.e.* the whole of those fibrous and fleshy parts which form the outer part of the intestinal canal, as well as the mesentery, the thin fibrous membrane by which the intestinal canal is connected with the ventral side of the vertical column. IV. The fourth or intestinal glandular layer gives the intestinal cellular covering, with the lungs, liver, salivary, and other glands.

Thus do egg-cells accomplish great things. They feed, they increase in size. They divide. They multiply. They advance in certain directions, and build up typical forms. They bend, they differentiate. They form two layers, they form four layers. They take up in each layer at each point the measure and kind of food they need for their special place and work. They begin to weave their respective parts and tissues. They advance steadily. Each part builds up, and in a marvellous manner collocates, the portion of the fabric required of it until the whole is completed.

Consider here (1) the greatness of the work the ovules perform. The burden laid on them is overwhelmingly heavy. The structures they have to raise are, we are ready to say, of a complexity requiring infinite care and skill. The bodies of a dog, an ox, a horse, a man are magnificent. Their systems of bones and joints, of muscles and nerves, of flesh and blood, of internal organs and external senses, their general strength and power

of motion, the perceptive power and intelligence they manifest, form an astounding outcome from the tiniest of sources. In the processes of building the advances are numerous, the number of stages is great, the amount of differentiation is enormous, the minuteness of the various kinds of cells, their fineness and suitableness, their differentiation taking place at the right point in the right manner, exhibit to us phenomena the most amazing. And yet as far as science sees, the characteristics and energies by which results so varied and on so great a scale are produced, are laid up in the ovules. In them are concentrated the wonders that develop into the animal. There must be in each sperm and ovule relations of form, there must be relations of sperm to ovule, there must be such a placing and balancing of forces, that in a suitable environment each kind cannot but operate and advance, and differentiate and build, until it builds up its own proper organisations. There must be in them a constitution measured in all its parts, adjusted for the production of every advance and differentiation, for making them at the right moment, at the right point. In this work the egg-cells do everything which we naturally and necessarily ascribe to mind. They select, they measure, they shape, they collocate, they adapt, they adjust.

They select from nourishment the right materials for flesh and blood, and skin and bones, and muscles and nerves, for heart and brain, for liver and lungs. Their is selection on a large scale, and requiring the nicest discrimination. They *measure.* The sizes of all structures are carefully attended to. The length and thickness, the fineness and strength, of the various fibres are accurately determined. A law of symmetry is beautifully observed. Corresponding parts are built up of the same size, and

different parts are proportioned to each other. They *shape*. What artist can approach them in many of their fashionings? They *collocate*. With unerring accuracy they set every fibre and organ in its own place, every part of fibre and organ at its own point. How many and how marvellous are the collocations, in the eye, the ear, the hand, yea throughout the whole body. There are ten thousand such. They *adapt*. They adapt organisations for their functions. They build them up of such materials, shapes, and activities as are suitable for the peculiar work they have to perform. They *adjust*. They adjust fibre to fibre. They fit bone to bone. They bind fibre to fibre, bone to bone, in the most suitable way, by the most simple and skilful means. They thus act as from minute and perfect knowledge of each frame. They know and unerringly recognise every stage they have reached. They know and unerringly recognise, at every stage they have reached, what is next to be done. They act as from a knowledge of the body, which anatomists and surgeons might well envy in the case of the human frame, which their splendid labours and assiduous studies have never enabled them to reach. The amount of selecting, measuring, shaping, collocating, adapting, and adjusting which falls to them to do cannot be made too much of. The amount of knowledge, foresight, discrimination, imagination required is such as no architect ever dreamed of possessing. Where, then, is the knowledge laid up? Where is the intelligence possessing it, and endowed with the power of turning it to account? Carbon saith, It is not in me. Hydrogen saith, It is not in me. Oxygen, nitrogen, and all elements, protoplasm and protoplasmic ovules protest, It is not in us. All with one voice confess that they know not, neither do they understand. They know not

what they do. They understand not the processes they carry on. They are unconscious of the brilliancy of the work they perform. They possess no knowledge, practise no foresight, exercise neither discrimination nor imagination. They select not, measure not, shape not, of their own mind. Where, then, is the wisdom to be found, and where is the place of understanding? Where, but in an eternal mind to whom belongeth knowledge and whose understanding is infinite.

(2) Consider the ovules. In whatever way these ovules are formed, what can we say of them but that they are works of infinite art? They are gems of construction. They are matchless marvels of likeness and differentiation. They are triumphs of concentration. They are, if possible, greater wonders than the bodies they construct. The potencies and arrangements necessary to the building up of each living creature are laid up in them in innumerable minutest points. In the case of the simplest organisations the ovules are doubtless proportionally simple. As the organisations increase in complexity, the ovules, which build them, must be increasingly complex, and have a greater wealth of order and potency stored in them. Were it possible to arrange in a line all the ovules of the animal world, beginning with the simplest and going on to the most complex, they would form a long and incomparable series. There are millions of them, and every individual is seen in the light of the work it performs to be a transcendent wonder. The mind revels in considering and imagining the wealth and perfection of forms and the balancings of forces in them. The intellect exults as it recognises order so dazzling. To its eye ovules are, as we have said, kings. They sit on thrones. A halo of royal potency is on them. The splendour of the greatest *chef-d'œuvres*, of the most

brilliant sculptures and works of artist hands of all the ages, is lustreless in comparison with the imperial order that shines in them, the imperial potencies stored in them. They have in their form, as revealed by the skill and power of their operations, incomparably more to transport the mind than the choicest gems in the sphere of art. And it is the amount of order concentrated in them, concentrated and differentiated into so great a multitude of varieties, the amount we dare to say of mind that shines in organisations so complex, that pleases mind. It sees its own image in them in supremest manifestation. It beholds the greatest triumphs in its own kind of work. It perceives that there are in them measurings, and adjustments, and settings, and touches of art, that belong to a higher heaven of invention than any to be found in works from the hands of human genius.

No sane intelligence would dream of the simplest house being built, without eyes, and an understanding, to see and measure. And no house, however large, however many its rooms, chambers, and passages, and however fine its workmanship throughout, can be compared with ovules in themselves, or the bodies which they build. And it is no sufficient explanation, it is overwhelmingly insufficient, to say that the work is accomplished by forces in the elements. The scientist may see nothing else with the eye of science. He confines himself to the study of the processes which he can explain by physical means. He sometimes refuses to go deeper. But deeper questions cannot be legitimately ignored. Every scientist, as in the case of the ether, is ready to ask any question, however deep, if it can be answered by referring to or postulating physical entities or causes. He only refuses to ask them, if in order to give the answer it becomes necessary to postulate the

existence of a nature other than physical, an entity of a higher order than material. But the true and complete scientific spirit requires us to demand for phenomena of every kind a suitable and sufficient explanation according to its kind. The phenomena of light and heat, borne from the sun to the earth, carried through spaces where ordinary matter exists not, require of us that we acknowledge the existence of an element suitable for conveying them, an element possessing properties such as can explain the phenomena. We cannot see the ether. We cannot feel it. We cannot perceive it as in the case of ordinary matter. But its activities in yielding light and heat make its existence and chief characteristics clearly and certainly known. And so, though we cannot perceive by any of our senses the mind that is at work in the midst of and producing nature's wonders, that is no reason why we should not admit its presence, if, as in the case of the ether, we see signs of its action. We ourselves are not wholly material beings, bundles of material forces. We are more mental. In us the greatest thing is mind, the greatest and most outstanding. By our mind we understand physical work, and that, when physical work is done, it must have a cause. We understand mental work also, we can recognise its signs, and that where these are mind must be or must have been. And we cannot but ask an account of the order and marvellous amount of adjustment and intricacy of adjustment in ovules and organised bodies. The phenomena are there. They are altogether of the kind which mind produces. They evidence themselves by the senses to the intelligence. They are as real and certain as those which proclaim the presence of light and heat and tell of the ether. They are light. They shine with surpassing splendour. They dazzle. They astound. And they are

not lying about as if they had existed in the same condition from eternity. They come into being. They cease to be. They are perpetually appearing, disappearing, and reappearing. The earth is a vast factory ceaselessly producing triumphs of art. There is the same activity of present operation as in the case of light and heat. They must therefore have a cause in harmony with their nature, operating in some way, at some point. What nature then can yield such phenomena, can so brilliantly measure and adjust, build up and organise? It is as necessary to postulate a nature that can do these things as one that can carry light and heat. It does not belong to blind matter and its forces to work of themselves in this fashion. They are not of the nature to do so. The nature acting must be determined by, must of necessity correspond with, the phenomena. It must be mental. The phenomena are, we say, the phenomena of mind, the signs are of its presence and action.

The activities of ovules and protoplasmic cells are endlessly rich and varied. They carry on their operations with transcendent skill, as if possessed of intelligence of inconceivable power. There is no work like unto their work, no masonry, no weaving and fashioning like theirs. Their every step is as if they were guided by the perfection of wisdom. In their action there are many physical forces playing a part, showing their respective characteristics. We can perceive them. We can determine their nature. When we see signs of their presence we do not hesitate to affirm that they are there. For physical phenomena evidently manifested, a suitable and sufficient cause must be found. And are we not as much bound to seek a suitable and sufficient cause for phenomena as real and far surpassing them in brilliancy? The phenomena with which we are dealing are not few and

faint and feeble, having only a semblance of order, a suggestion of an intelligent hand. They are many as the sand that is on the seashore. They are of immeasurable clearness, perfection, and force. They are the most striking of their kind that exist. They are the most striking of any kind found in the natural world. There are none that can vie with them, none that are not feebleness beside them. They are so brilliantly clear, so forcibly striking, that they compel us to have respect unto them, to acknowledge their transcendent splendour, to stand in awe and sin not against their majesty, to seek for them an origin worthy of their rank, a parent corresponding to them in nature and kind, a cause of their being of their own loftiness, and to be found within their own realm. And to what do we naturally ascribe them? Of what are wealth of order and complexity of adjustments and organisations the natural signs? Are they not the natural signs of mind? Are they not the highest rank and fashion among its children, the aristocracy, yea, the royal race among its sons? They are not as the arrow flints and axes, from which geologists do not hesitate to draw conclusions. They are not even as the greatest works of human genius. They surpass them, and are more widely separated from them in glory than they are from flint arrows and stone axes. Yea, it seems as if He who made all things determined to put into them a wealth of order and signs of mind such as might render it impossible for mistake to be made. Nothing conceivable or inconceivable save mind can have produced phenomena so transcendent in brilliancy, so infinite in force.

IX

THE PERCEIVING AND PERCEIVED NATURES

The Senses—The Brain—The Elements in it—A Special Element — Union to the Brain, Perfect, Stable, of Unlike Natures—Correspondences in Perception; Many, Varied—Power of the Perceiving Nature — Many such Natures — Sensations caused by Numbered Motions.

There are perceiving natures. We are conscious of possessing perceptive power, conscious each one of our being as exercising it. We know, and our own existence is not more certain than that we see, and hear, and smell, and taste, and touch.

There are phenomena perceived. There are colours, sounds, tastes, smells, and the sensations of touch. The existence of material substance may be denied, but it is impossible not to acknowledge that there are phenomena.

Through our perceptive power we become acquainted with a universe rich in beauty and grandeur, and crowded with objects of intellectual interest. By day the sun shines in his strength, lights up the earth, and robes it in a garment of many-coloured loveliness. Sunrisings and sunsettings charm by their dawning and waning softness, and kindle an enthusiasm of admiration of their hues on hills and clouds. By night the moon walks in fairness, or the stars sparkle in brightness. By day and night the beautiful blue sky, most majestical of canopies, looks down on us. Mountains rise to varying

and sublimest heights, mantled in green, purple, and white. Valleys and plains are clad in verdure many tinted, are clothed with corn, are watered in blue and silver and gold. Living forms lie or walk, run or fly. Great is the extent of view, multitudinous the objects, which the eye from a mountain top can command. By the ear we become acquainted with a wealth of sound. Every object struck yields its own variety. Every living creature has its own cry or note. Beautiful, noble, and sometimes thrilling are the tones of the human voice in speech and song. Entrancing are the great compositions which musical instruments are made to render. By day the lark captivates the listening ear. The song of the nightingale is by night seasoned to its right praise and true perfection. Sweetly smell the rose and the briar, flowers many, shrubs many. Festal to the taste are fruits, and foods without number.

When the things perceived are investigated by the intellect, many facts and laws are learned regarding them. In every perception of the objects of the external world, there is the action of the material elements, of the bodily organs, which form the machinery of communication, and of the perceiving nature. In the case of the two former it consists in forms of motion. Light and colour phenomena have their origin in the sun. Heat of tremendous intensity, molecular motions, compared with which whirlwinds are calmness, agitate a great ether sea, dash it against solid particles in the flamés, and generate light vibrations. These are transverse, and at every point vary in numbers from under four hundred billions to nearly eight hundred billions per second. According to the numbers of the motions in the molecules which they strike on the earth are the numbers of vibrations forwarded from them to the eye, and the

colour impressions made. Reaching the eye in numbers far beyond any that can be numbered, they enter it in perfect order. The eye is a little round ball. In it are two lenses filled with crystalline liquids, and many arrangements for effective working. At its back are the retina and nerves, which pass to the brain and convey the motions to it.

In sound perceptions there are the motions generated by blows, voices, and instruments. These are carried by the air, and enter the ear. The ear has many parts. There is the canal, the drum membrane, a cavity within it, surrounded by bones, and filled with air, which is renewed by a tube passing to the pharynx. Further inward are a hammer, an anvil, and a stirrup, a second membrane and labyrinth filled with liquid, in which are nerves in many thousands running to the brain. Sound waves enter by the canal, strike the membrane, and agitate the air within. By it the hammer is made to strike the anvil, the anvil the stirrup, the stirrup the second drum, and so the motions are communicated to the liquid within, and from it pass along the nerves to the brain.

Thus also through their organs do the motions reach the brain, which cause the sensations of smell, taste, and touch.

Among organs the brain is the most complex. It is the seat of perception and all mental energy. Without its suitable action, consciousness in the body is impossible. It is large in size. In man its average weight is 49½ ounces, in woman 44. In the surface of the brain is grey, cortical matter, cellular in form, and closely connected with mental action. Within is white matter, consisting of masses of fibres regarded as transmissive. The ingoing nerves from the senses end in the grey

matter, amid its nerves and corpuscles. The nerve fibres of the brain are in hundreds of billions, and there are cross fibres by which they communicate with each other. The perceiving nature connected with it receives from it all its impressions.

In sensations, therefore, motions begin in the external world, are conveyed by complex organisations to the brain, and by it to the perceiving nature.

The perceiving nature has no consciousness of the motions forwarded to it. It does not perceive the number, distinguish number from number, and so interpret them. It perceives not motions of any kind or anywhere. To it light motions shine, harmonic motions make music, those of touch press, those of taste feast, those of smell regale. The natural result of moving particles and an active ether is to generate motion in that on which they act. Here, however, they produce impressions, which differ, *toto cœlo*, from mere motion.

It is not necessary to our argument to affirm anything as to the nature of the substratum in which the perceiving nature inheres. Materialists maintain that it is material, that the molecules of matter in certain forms of excitation in the brain give birth to the consciousness of perceiving colours, sounds, tastes, smells, and the sensations of touch.

We have seen that the elements of matter are revealed to us as accurately measured in their forces and modes of action, as carefully and exquisitely adjusted to each other, as a scene of brilliant order throughout their fields, and therefore as clearly testifying that they are the work of mind. And if conscious perceptive power be an evolution from certain kinds of material particles, it forms a magnificent addition to the evidence for their being made. It makes manifest that there must be stored in

the atoms the potencies necessary to the production of the results. If we thus endow material elements, if there be in them such characteristics as enable them to rise to the height of yielding perceiving natures, we enrich them with riches above what is seen in them in any or all of the sciences. To what then do they owe the possession of qualities so high? How did it happen that all carbon atoms, those also of hydrogen, oxygen, and nitrogen existed, having each their own kind of potency, which enabled them to develop, by combination and organisation, powers so exalted? It would be a phenomenon the strangest if two independent suitable entities chanced to exist from eternity in a condition and so adjusted to each other, as that coming together they should yield one perceiving nature. It would be still stranger if a number of independent atoms were found capable of so high a development. It would make manifest in each such qualities and adaptations, that we could not believe in them as so existing by chance. But there are four different kinds of atoms, and there are of each kind numbers to which the drops of all the seas are but as fewness itself. And one and all of each kind have something which, when they are united in a peculiarly complex chemical union, and built up into the supreme organisation, yield, in some mode of united action, the perceiving nature. Every atom of carbon, hydrogen, oxygen, and nitrogen, if on the earth or in the sun and stars, has its potency capable of contributing to the result. These potencies are of a very lofty and special nature. Here lovelier beams than its diamond crystal knows, spring from carbon. Here in a combination and organisation of this and its colleague elements, it is as if a nightingale's note or grand symphony were to proceed from a clod of the valley. The same specialty dis-

tinguishes each kind—the same in nature, rank, and force. Every atom of carbon has the brilliant carbon peculiarity or peculiarities. Every atom of oxygen has the oxygen characteristic, of hydrogen the hydrogen distinction, of nitrogen the nitrogen potency. In such part of a single brain organisation as is necessary to conscious perception, the numbers of each element are enormous. And every atom has its part to play. From one and all rays or activities proceed, and these concentrating in some inexplicable manner, kindle the perceiving nature. Whence then similarities so high and extensive? Whence the perfect likenesses of qualities so special and in numbers so vast? Whence the measuring, and adjusting, and adapting of the characteristics of four elements, so as to fit into each other, and be gathered from all parts of the complicated and multitudinous fibres of the brain, and formed into so sublime a unity? That potencies so high should be found in a few atoms of each kind is beyond belief. That all are distinguished by them, and in every one of the same element, accurately of the same measure; and that there are four qualities, or whatever the numbers may be, adjusted to each other, and adapted for uniting and combining, and being organised so as to yield a product so lofty, no language can express the force with which chance is excluded, the absoluteness of the impossibility that anything but a great intelligence could account for the bringing into being of such phenomena.

That atoms are capable of forming the brain organisation shows them richly endowed, but they are much more so if they be the substratum in which the perceiving nature inheres. They form in the brain compounds the most complex and fibres in millions. The albuminous matter of the fibres is highly unstable, is unstable with

an exquisitely measured and suitable instability, and fed by the blood in large quantity; the decompositions that are produced, the new combinations that are formed, the motions that run along fibres, and from fibre to fibre, are in numbers and kinds, in variety and order, of over-mastering brilliancy. Great is the work to which they thus attain. Great are the burdens they bear. Their responsibilities are such as to require them to be marvels of constitution. Considering them as ordered only for the building up of the structure of structures, the crowning organisation of the world, for the part which we know they play in the operations of our internal nature, for the execution of the multitudinous motions and changes which take place in perception, our admiration is kindled, our wonder inflamed, and we are forced to conclude that they are the children of mind. But if we ascribe to them also the potencies necessary to their being developed into perceiving natures, still more if we add the powers of thinking, feeling, and willing, we increase the burdens laid on them enormously, we require that there should be in them potencies leaving mechanical and chemical properties far beneath, and make the atoms of carbon, oxygen, hydrogen, and nitrogen as stars of glory among their fellow-elements, gems lifted up to the highest heaven of activity and work, a transcendently glorious product of divine Intelligence.

On the materialistic theory, indeed, these atoms are exceedingly marvellous in the character and rank of their potencies. Nothing is too wonderful for them to do. They draw to each other. They cling together. They act chemically. They spring into union, and form many combinations. They strike each other and other particles, and strains of music pour from them. The ether, sun-moved, strikes them, and they glorify it, and send it

from them glowing with colour, kindled into every loveliest hue. But, according to materialism, they are not satisfied with trophies so splendid. They press onward and upward. They climb to higher and ever higher work. They build up protoplasmic forms, and generate protoplasmic life. They construct cells which put to shame the most brilliant triumphs of human art. They form organisations that rise above, and outdo the mightiest triumphs of human genius. They yield perceiving natures and intelligence in the animal creation. They rise to the exercise of intelligence of the highest order in man. They climb to heaven. They ascend to the heights of the Most High. They burn and shine with heaven's purest thoughts and feelings. They not only play their part in yielding natural light and heat, but in the loftiest form of their excitation and motion they give birth to the beauties and grandeurs, the savours and odours of perception, to the noblenesses of thought and the fervours of love. Thus endowed, they are elements imperial in potency. They are elect atoms. They are among their fellows as pearls among grains of sand, diamonds amid bits of glass. There is not one feeble among them. They are all strong with their own peculiar strength. There is not one common and low. They are all capable of rising to ethereal heights of work. There is not one dark. They are universally illuminated with the light which breaks forth into the enlightenments of consciousness. Endowed with potencies so high, they outshine, each particle of them, millions of atoms though bright. They are products of mind, of a mind of transcendent greatness.

It has been maintained that carbon is the chief factor in yielding life and its powers. It is the atom of atoms, the elect of the elect, and therefore, as we have seen

before, and now more clearly see, most evidently made. But the other three elements have relations and nice adjustments to it, which are necessary to the kindling of its fires and the calling forth of its activities, and therefore must also be made for it. Whatever part the ether also may play, it requires adaptation for it, and the same conclusion must be drawn as to it.

But the perceiving nature is rather an element by itself, a form of being of a higher kind than matter, of a nature corresponding to its powers, and such as would naturally possess them. The laws of light are widely separated from those of ordinary matter, and scientists do not hesitate to postulate the existence of an ether capable of acting according to them. The laws and action of the perceiving nature separate it by a gulf wider far from the atoms of matter and from the ether, and it is the only philosophic conclusion to which to come, that it is a nature of a higher kind, an element corresponding in its essence to the powers it exercises. In light sensations it is motion that is created in the sun and ether. Motions fly through the latter to the earth. Motions rebound from the earth to the eye. Motions pass through the eye to the retina, and along the nerve fibres to the brain. Motions are excited in the brain. But in whatever way they strike the perceiving nature, they are to it not motions, but light and colour. It has no consciousness of being stirred to activity of any kind, but of experiencing these sensations. In like manner, sound motions, those also of smell and taste and touch, are so until they reach the brain, and in the brain, but to the perceiving nature they are sounds, smells, tastes, and the sensations of touch. The change is entire. The transformation is complete. The effect produced on the perceiving nature is altogether different from that on

any part of the means and instrument of communication, on any part which we know to be material. There is no likeness between motion and sensation. There is no resemblance between vibration and colour. They have nothing in common. The difference between them may be said to be infinitely great. Of necessity, therefore, the entities to which they belong must be as different as the qualities are different. And as the faculty of perceiving matter in so many of its phases is supplemented by powers still higher, and if possible more widely different, we are constrained to conclude that there is in mysterious association with the brain a nature whose substratum is not molecular and material, is not of the nature of the ether, but such as to be denominated mental or spiritual, corresponding to the powers with which it is endowed. This nature is most intimately united to the material form, and through it perceives the ten thousand wonders of the world.

(1) *The union is perfect.*—They cleave to each other. They work together. They co-operate in all operations as if they were one. The one can do nothing without the other. Their action is uniformly a combined action. In the healthy nothing can surpass the perfection of their harmonious working. They are as a perfect instrument and instrumentalist, as a grand organ and hand of matchless skill to sound it, from its lowest note to its full compass, from its simplest tones to its sublimest and sweetest combinations.

(2) *The union is stable.*—It is not like that of substances which the least blow or rise of temperature can break up. It is as the most stable compounds. It can continue for threescore and ten, or fourscore, or even a hundred years. The conscious perceiving nature does not dart from its place at an unpleasant sight, a harsh

sound, an offensive smell, a nauseous taste, a severe blow. The lightning perilously near startles; the thunder alarms, but does not drive it from its seat. Many tastes and smells strike it unto immeasurable disgust, but not unto falling from its throne.

(3) *The union is of unlike natures.*—The perceiving nature on the view we now present belongs to a sphere high above the organ of perception. It has powers high as heaven above every material element. And yet it is brought into perfect union with the brain, and they co-operate with, and minister to, each other as true yokefellows. Their characteristics meet as at mathematical points. Their properties are measured for each other, in order to union, with an accuracy as perfect as those of atom for atom, or of the ether for molecules. Atoms cling to atoms cohesively and chemically, and sometimes with exceeding great tenacity. No explanation can be given of the ordered action of these forces, save that the substances are so adjusted to each other as to act in this manner, are so adjusted by intelligence. But far more must we postulate adjustments of the most extraordinary nature, of the most exquisite perfection, in order to the possibility of stable union and combined action of natures so diverse as those of the perceiving nature and the organ of all perception, and far more must we ascribe these adjustments to a great understanding.

The correspondences between the two natures.—There are then two natures—the perceiving and the perceived; the subject and the object; the sense power and the phenomena of matter. All that follows is true, whatever view may be taken of the nature in which the perceptive power inheres.

1. These two powers are distinct and independent. The power of producing impressions is totally different

from the capacity for receiving them. Perceiving and being perceived are as at opposite poles.

2. The one does not exist because of the existence of the other. The perceiving nature does not by an act of its own will, or the forthputting of its power, call matter or material phenomena into being, and the perceived qualities do not create the power of perception. Even materialists cannot affirm that the fact that the one kind of power or qualities existed rendered it necessary that the other also should have being; that the potencies of matter and of the ether in yielding light, sound, music, tastes, and odours, created the power of perceiving them. They might be the means of developing but not of originating it. It is not, therefore, of necessity that the one has being because of the existence of the other.

3. From this it inevitably follows that correspondence between them is not of necessity. It is not of necessity that there should be in matter its various characteristics, and side by side with them a perceiving nature, and so it cannot be of necessity that, in the accidental case of two such natures existing, there should be any correspondence between them. If they do correspond it must be by chance or design. If each nature finds its exact correlative in being and by its side, it is not owing to itself, but to a wonderful coincidence or an intelligent mind.

4. Their correspondences are superlatively remarkable. The power that lies in material elements to produce in perceiving natures the sensations of light, colour, sound, taste, and smell is not a natural one. It is comparatively natural that molecule should act on molecule, and even that ether motions should pass over into molecules that have certain likenesses in action to itself. But the potencies of making and receiving impressions are much farther from each other than molecules from molecules,

or molecules from the ether. The latter is separated from the ordinary forms of matter by the very greatest differences in the measures of its activities, but its forces and modes of action are on the same lines. The perceiving nature, on the other hand, belongs to a different region altogether from the perceived. Their properties are not on the same lines; they are not in the same plane; they do not lie in the same world. The effect that passes from material elements to the perceiving nature is not motion produced. The impression made is not a continuation of the same kind of action as is in themselves. The potencies of the two natures are as at opposite poles, and may be said to be at an infinite distance from each other. And yet they meet, and the characteristics of the one fit iuto the powers of the other with perfect exactness. They meet as if they were of the same nature, belonged to the same world, and showed the same kind of action. They are fitted for each other as "for the dove its dell, for the swan its lake," for the bee its honey. The one produces on the other the most singular and varied effects, beams on it with light and colour, streams on it in sounds and harmonies, delights it with tastes and odours. The perceiving nature is exquisitely adjusted to the perceived, and the perceived to the perceiving. The perceived, advancing from afar, strikes the perceiving, as it were, in its centre, strikes it unto amazing and pleasurable excitation. The motions of matter and of the ether are found capable of springing across the widest of gulfs, of mounting upwards to the loftiest heights, of making a nature far above them their aim and reach, of rising to it on strong wing as if divinely raised and supported, and of producing on it the most magnificent and charming impressions. They are found capable of acting not on

each other only, but of ministering to beings of a higher order than their own, of creating not motions alone, but the most marvellous sensations. To the contemplative mind, dwelling on, and alive to, the inexpressible wonderfulness of the exactness of the meeting of two natures so diverse, the exquisiteness of the adjustment to each other of entities so widely apart, the ineffable beauty with which the one, passing over an immeasurable space, acts on the other, kindles splendours for it, makes music to it, exhilarates and feasts it, it seems the most impossible of all things that anything but a divine intelligence can account for such phenomena.

5. Their action is perfect. Seeing, hearing, tasting, smelling are performed in a manner which nothing can excel. The clearness and cleanness of all sensations in persons of healthy constitution are crystalline. Beholding an extensive prospect, no blanks appear, no blotches offend. There is no dimness of vision. There is in ordinary circumstances nothing dazzling and intolerable. Light is sweet to the eye, and it is a pleasant thing to behold the sun. Who can paint like nature. Colours are set before us with a perfection which reaches the supremest beauty. Not a flower blooms but shows touches, hues, streaks, and stains that make manifest the hand from which they come, the mind to which their tasteful loveliness is due. There is no dulness in sounds nor ordinarily anything of an overpowering nature. The vast multitude are possessed of a sense of hearing, to which common sounds are splendidly distinct. Music knows tones the grandest and sweetest. When a great instrumentalist, instrument, and orchestra render the masterpieces of genius, perceptive natures listening are regaled by cluster on cluster of harmonies, in which neither blank nor discord finds a place. Balmy and

refreshing odours delight the sense of smell, delicious tastes the tongue and palate. Only in age are sensations enfeebled, showing what might have been, and that it might easily have been impossible for any sensation to be developed. Everywhere in the ether and air which carry light and sound, in the instruments of conveyance, and in the perceptive power, the action is perfect. Nowhere in the strong is there the least disorder, the least intrusion of chaos. Vast multitudes of independent elements have part in every sensation, and yet the result is the very ideal of work matchlessly devised, perfectly achieved.

6. The correspondences are many. There are in the perceiving nature not one but five or more senses, and, corresponding to them, an inexhaustible variety of characteristics in matter. These senses are widely apart, and as far separated are the material characteristics. No faculties can less resemble each other than those which operate through the eye, the ear, the nostrils, the palate. Colours and sounds are wholly unlike, and both differ as much from taste and smell. The perceiving powers are so widely apart that there can be no absolute necessity that they should be bound together in the same bundle, that they should be conjoined in the same substratum. The characteristics of matter are so separated from each other that there can be no necessity that they should exist side by side in the same molecules, that there should be in them the power of acting in five different ways on the perceiving nature.

There might also have been perceiving natures differing from those with which we are endowed. The range of possibility is infinite. The number of might-have-beens knows no limits. We cannot conceive any kinds save those of which we have experience, but we cannot hesi-

tate to acknowledge the possibility of their existence. And, *à priori*, there was as much probability that any other possibles should exist as that they should. There might therefore have been perceptive powers, and none of our present system among them. There might have been innumerable conjunctions of twos, or threes, or fives, and all different. And in like manner there might have been as great variety of differences in the qualities of matter. There might have been a perceiving nature possessed of one sense, and nothing to produce any impression upon it, or many senses and nothing to affect them. There might have been countless systems of perceptive powers and countless systems of material properties, and no correspondence of any kind, or anywhere between them —the perceptive powers and material properties being at an immeasurable distance from each other's range. And yet the system existing has five perceptive powers, and the material elements have propertiés suited to them all. They are so far apart from each other, the possi bilities of existence of different senses are so countless the range of possibility in material motions is so unlimited, that for the latter to be capable of producing a single sensation in one sense involved chances against it above all numbers. That there should be two senses and motions of one kind corresponding to each was much farther from probability, but that in the same perceiving nature there should be five senses and motions in the same matter corresponding to each and all, was absolutely impossible as the result of chance.

But for each sense there is not only one sensation but many. Those afforded by the power of vision and colour are multitudinous. By the eye we perceive red, orange, yellow, green, blue, indigo, and violet. There are also of these a great many combinations, a vast variety of tints

and hues. To the eye they are distinct. They are entirely different sensations. They are easily discriminated. A perceptive power capable of perceiving the constituents might have been incapable of seeing a distinctive hue resulting from their combination. By the ear we perceive a variety of sounds. Every object struck has, we have seen, its own clang-tint. The human voice and instruments yield a myriad differences in speech and song and musical compositions. And every variety, every different impression made, requires differences in the motions forwarded, and a distinct feature in the perceptive power, a distinct measure of capacity of being acted on, in order to the impression being made. We might have had a nature capable of being affected by, and such as should distinguish impressions made by, two or three varieties and combinations of sound, and not necessarily by more, but the number is very great. Great also is the variety of tastes. It is said that if one were to taste five hundred wines, no two would be found exactly alike. And so the number of distinguishable tastes must be very great. Many also are the different odours.

Sensations differ in intensity.—In the case of any colour it may begin at the faintest and rise to the deepest dye. It is in one object so feeble that we can with difficulty recognise it. In another it is glaring or dazzling. Between the extremes there are many degrees. Our perceptive power thus operates within a certain range. It might have been much smaller or much larger. It might have been limited to its present medium and a few degrees on each side. Or it might have occupied the same range as at present, but with a discriminating power so coarse as only to distinguish between two or three degrees. Each degree therefore of the perceptive power, and of the intensity of colour perceived, is a separate

correspondence. The same things are true of sounds, tastes, smells, and thus we have a multitude of correspondences. Taking all these considerations into account, we find ourselves possessed of a perceptive nature surpassingly rich in potency, and in the presence of characteristics and motions in matter in endless variety. There are correspondences between them which are as the dust of the earth for number. If then against the conjunction of five senses or even two finding one form and measure of material activity suited to them the chances are overwhelmingly great, how shall we set forth the impossibility of the conjunction by chance of countless varieties and measures of potency in each of five senses, and corresponding to them innumerable motions suited to their excitation existing in the material world.

7. The perceiving nature is of vast capacity. It can receive at the same moment a multitude of impressions. It might have been capable of taking over from the brain and organ of vision only a few beams of light. It might have been able to see only a point, a little spot, a tiny flower or garden, and then it would have been comparatively narrow and poor. Instead of this it is on the grandest scale. From a lofty vantage ground we can command a view embracing the widest plains, a multitude of mountains, and the blue vault of heaven. We can turn round in a second or two, and see instantaneously afar on every side. Lines of light, we have seen, have each hundreds of billions of transverse vibrations at minutest points. In a second the hundreds of billions in a line 180,000 miles in length enter the eye. They are counted by centillions multiplied by centillions. Those entering from a flower are counted by still larger numbers. Inconceivably vaster are the multitudes pouring in from an extended prospect. Great also is their variety. In viewing it therefore the

number and variety of motions passing over from the brain to the perceiving nature are inexpressibly, immeasurably, overwhelmingly great, and yet so vast is the capacity for receiving them, so perfect is its adaptation for dealing with them, so regal is it in power, that, with matchless ease and smoothness of working, it receives, deals with, and interprets and transfigures them after its fashion. Let us consider and endeavour to imagine the riches of the glory of this ordered action between the perceiving and perceived natures, the amount of it, the fineness of it, its transcendent rapidity and perfection. Here is capacity for receiving great as the sea, rapid as the light, refined to its fineness, adjusted to the exquisiteness of its adjustments. Here is an inflow of motions, more multitudinous than the molecules of all earth's rivers, and their motions. The most extensive and admired outward view is surpassed by the small yet inconceivably great volume of activity passing through the eye, the retina, the nerve fibres and the brain, but above all by the final action on the perceiving nature. Here in an instant more work is done than by all the machinery of the world in days. It is accomplished with sublimest ease. We open our eyes and look and feel as if no force had been expended. It is divine work. Beside it the "that" of Michael Angelo is vanity and coarseness. In presence of phenomena of such rank, how can it be said that there is nothing more to be seen than the eye of science recognises, that no sound is uttered save such as it hears, that these phenomena are to be regarded as phenomena and nothing more. We can learn nothing of whence they are. They are meaningless, they are silent, or their answer to the cry, Who hath called them, and set them in order, is that of the Cyclops of old, *Οὔτις, οὔτις, οὔτις*—No one, no one, no one! The mason squares his stones and makes them fit for building. The

work is rough, the surfaces are uneven, yet is there unmistakable evidence that he has worked with intelligence. Great is the difference between the signs of his hands and those which genius imprints. But the difference is infinitesimal compared with that between the most brilliant triumphs of human art and those which flame out on us in the operations of perception, in its magnificent power of dealing with the multitudes of motions that come to it in a second from hills, and plains, and woods, and fields, and streams. Is it then to be said that no art is needed for the art supreme, for triumphs which a whole world of genius could not produce in an eternity? Nay, assuredly, nay. These phenomena are not meaningless. They mean intensely. At a glance order is seen sufficient to transport and raise to the whitest heat of admiration. And as the eyes of the imagination gaze, and of the understanding open, a hand breaks into view brilliant as the sun at noonday, yea as the light of seven days, a hand that, when seen, writes the name of God on the brain and heart for ever. They are not silent. They speak. They sing. They are as a chorus of myriads. They articulate, and name the name that is above every name with a clearness and force and awfulness as of that voice from Sinai that made Israel remove and stand afar off.

In like manner our perception of sounds might have been narrow and poor, but instead our perceptive nature can perceive, and take over, and transform the motions created by a grand instrument and orchestra, the multifarious sounds of a multitude making holiday, and the mighty volume of the thunder's and ocean's roll. The senses of smell and taste might have been capable of nothing more than a touch at a point. Both, however, are on a liberal scale. Thus in the case of all the senses the amount and fineness of adjustment between the per-

ceived and perceiving natures, the vastness of the capacity of the latter to receive the vastness of the multitudes of motions coming to it from the former, bears overmastering testimony to the all-transcending glory of the understanding that made and adapted them for each other.

8. But there is not merely one perceiving nature. There are trillions of them, of a great number of genera and species, and all possessing powers of the same kind, and in the higher animals very much within the same limited range. They are attached to material forms, and use similar material organs. If they be developments of matter, they make manifest, as we have seen, the riches of order and potency stored in the primal elements which have yielded them. If they be elements of a higher nature, as seems irresistibly evinced by scientific considerations arising from their action being separated, *toto cœlo*, from all known forms of molecular and ether activities, many questions arise as to whence they come, where they lie, how they become attached to material frames, questions some of which cannot be answered. That, however, with which alone we are concerned is the field here presented to us of correspondences surpassingly perfect, correspondences many as the molecules of matter and the ether vibrations, correspondences of the most remarkable nature, between perceptive powers and objects perceived, forming an overwhelming argument for their being made and adapted to each other.

9. The motions involved are to be considered. Those of light are carried by an ether in which the illuminating vibrations range from under four hundred billions per second to nearly eight hundred billions. As far as the perceiving nature is concerned, no ether might have existed at all; or, if existing, it might have had such properties that its vibrations might have all been in

thousands, not hundreds, of billions, or even any numbers beyond. They might not have reached three hundred and ninety-five billions, nor three hundred, nor one billion. In like manner, atoms and molecules might have existed, and no motions in them, or motions far from any relationship to those of the ether, far from such a relationship as to enable them to give birth to the motions that produce light and colour. In short, there might have been neither ether nor matter standing in any relationship to each other, or to the perceiving nature. It might have been impossible for the three to have been found in a condition fit for harmonious interaction. There is no limit to the imaginings of the different ranges which the perceiving and perceived natures might have occupied, and no limit to the imaginings of the variety of conditions necessary to their being adapted to each other; and so there is no limit to the number of chances against the three meeting for light-giving. That there are not merely two but three entities involved adds incalculably to the force of the argument. In like manner, the motions of matter might have been out of all relationship to the capacity for perceiving sound. They might easily have been of a velocity too small or too great. They might have been the fewest in number or the largest. All matter might in like manner have been out of relationship to the perceptive powers of taste, smell, and touch. In short, the two natures might in their capacities and motions have been in an infinite number of ranges small or large, and at any measure of distance from each other. That the two are within the same range, that they are so in so vast a multitude of relationships, that there are in so many kinds of material molecules, and in so great a multitude of each kind, and in the ether, so unexhaustible a number of ways in which they can touch

innumerable perceiving natures, makes it impossible not to conclude that they were made for each other. It is impossible without skill to play on the simplest instrument. It is impossible for ignorance and chance and hands unpractised to do justice to a grand organ, so to govern its stops, strike its keys, and command its harmonies, as to captivate and delight cultivated listeners. And yet this is an easy achievement compared with the fitting of perceived natures to the perceiving, of so ordering the ether and multitudinous molecules of matter, that they should unite to govern its stops, strike its keys, command its harmonies, and produce in it the vastest variety of sensations; yea, that the earth and all that therein is, the ether and sun and moon and stars, should, as consummate artists, in all their hosts of particles and parts, unite to act upon perceiving natures without number, and fill the earth with the music of their working.

X

THE EVOLUTION OF SPECIES

Darwin—Factors in Evolution—Law of Progress—Selection—Time Element.

ATTEMPTS have been made to get rid of the conclusion that the organised world is the work of mind. Tyndal, Haeckel, and others have boldly maintained that the potencies necessary to its evolution are to be found in matter; that there is no need to go beyond it, or behind it, above it, or beneath it, to find a cause of its order. Haeckel, with fierce energy and great wealth of language and argumentation, with a high sense of his own superiority to weakness, with a lofty scorn of the black-coated fraternity and all the feeble-minded race who believe in an intelligent creator,—Haeckel fights for monism as for life. Atoms alone are; atoms have of themselves built up the great globe and all that it inhabit. Amongst atoms, we have seen, he gives the chief and ruling place to carbon. He places it on the throne. Coke is the lord of creation. Coke is the all-ordering maker of the vast kosmos. Carbon is the mighty atom. Carbon is God.

By the publication of *The Origin of Species* in 1859 Charles Darwin introduced a new era in the history of biology. The doctrine of evolution, which had been propounded long before, but had remained very much in the background, made in his hands a great leap forward,

and took the world of science by storm. With limitations and professions of uncertainty as to all the factors, it is now very generally accepted, though few ascribe to it the range and power in which Haeckel exults. He makes it everything. He regards it as sufficient, through the mighty power of carbon, to account for the most complex phenomena of existence.

The chief principles of Darwin's theory may be stated briefly. There is—

1. *The law of heredity or likeness of offspring to parents.*—Like invariably produces like. No law is more universally known and acknowledged. The seeds of a plant grow into the same plant. The eggs of an animal grow into the same animal form.

2. *The law of variation.*—"No being on this earthly ball is like another all in all." In every species of plants and animals individuals tend to vary from the specific type. No plant is wholly like another plant. No animal offspring, in all respects, resembles its parents or any other individual to which they give birth. There are variations generally in every organ, in every appearance, throughout whole bodies. In some cases the variations are considerable. By the law of heredity these variations are transmitted. A new species of short-legged sheep was produced in America at a single bound.

3. *The law of multiplication by geometrical progression.*—There is in many plants and animals the possibility of increasing a hundred- or even a thousand-fold in a single year.

4. *The law of limited populations.*—The number of every species is limited by the conditions or nature of the environment in which it lives, by the amount of food in it, and by the number and strength of the enemies which it has to encounter. A plant or tree may produce seeds

without number, but if the ground be already fully and strongly held, they cannot live and grow. The multiplication of animals is limited by the same principle. Over-population, excessive increase of any species, produces a struggle for existence. Seeds and plants contend for a place in the ground and for the nourishment it yields. Animals contend for food and other necessaries of life. The strongest varieties prevail. They assert their superiority, maintain their ground, seize the food. They live and flourish and multiply. They survive, and transmit their characteristics to their offspring. This is the law variously denominated: The struggle for existence, the survival of the fittest, or natural selection, by which nature selects and hands forward all improvements, and so advances.

5. *The law of unceasing change of environment.*—Even now no year or season is like another. There are seasons in which the greatest strain is put on the existence of various species, in which the struggle is of terrible intensity, and the weakest perish.

6. *Past time has been to all intents and purposes infinite.*—Many millions of years have passed since evolution began, since the first forms of life were quickened. Ample time and opportunities have been afforded for the advances made. Hence it is probable that the existing species of plants and animals have been evolved from a few primitive and simple forms of life, or probably from one form alone.

According to the theory of evolution, there was a time when life existed not on the earth. By chemical action, by a concourse of molecules of a very peculiar and complex nature, a concourse taking place in very peculiar and complex circumstances, such as no experiment can now discover, protoplasm came into being, and life was

generated. Protoplasm straightway began to act after its manner, to take in and grow, to divide and multiply. Amœbæ, though mere specks of this form of structure, claimed an independent existence, and showed themselves capable of performing certain of the functions of life. A great advance was made when a nucleus was evolved and cells formed. Cells learned to multiply, vary, and build up organisations. Organisations scored a triumph when they developed the power of producing seeds and eggs, in which they concentrated the means of reproducing their kind. By processes inconceivably slow, by gradations insensibly fine, exercising the patience, and careful with the care as of eternal genius, the patience and the care which alone produces what is enduring, evolution worked. Organisations became increasingly complex, multiplied their parts, tissues, and organs. As each kind increased in numbers, in fields in which room and food were limited, in environments in which were times of severity and enemies of power, there arose a struggle for existence. The feeblest perished. The strongest and fittest survived, and continued the onward progress. Onward, ever onward, the evolution marched, adding triumph to triumph. Thousands of years passed, tens of thousands, millions, during which variations without number were effected, and wonderful advances made. Organisations the most diverse, organisations the most complex and wonderful, with cells differentiated unto myriads of times, living, seeing, hearing, thinking, reasoning, and moral natures, came into being.

In the present order of things, the most highly organised animals are developed from germs in a few months. Their development carries the organism through the same stages as originally required millions of years. It reveals

the lines along which evolution advanced. It shows the various forms through which, in ages of ages, the original germ passed in its forward journey. The history of the embryo makes manifest the history of the species. Ontogeny, or the history of the individual, unfolds the course of the phylogeny, or stages in the advance of the tribe. From the germ to the perfect man, there were, it is affirmed, twenty stages.

In some such manner, according to the theory of evolution, have all species of plants and animals been gradually brought into being. But, supposing it true, the theory accounts for little, for comparatively very little. It deals principally with the manner in which the work has progressed, the laws according to which it has been accomplished. It describes processes; it states laws. But it does not account for the processes; it does not account for the laws. It gives no real explanation of the wealth of order and adjustment pervading the work from its first beginning on through its surpassingly perfect processes and triumphs till it is crowned in man. It assumes the existence of the elements, of materials the vastest in quantity, the most marvellous in quality, of materials so ordered as naturally and necessarily to grow into the great kosmos in the midst of which we live. All that has been evolved must have been originally in the primary elements. They had in them the potencies and measures; they existed in the quantities and conditions which sufficiently account for all which they have built up. They were so ordered on this view as to be capable of carrying forward the advances which have issued in a world of form and life indescribably rich and magnificent. It ascribes to them a glory of order of which of necessity an account must be demanded.

In the evolution of living forms the springing into

being of protoplasm is the first step. We have already dealt with it and its power of reproducing its kind, its power of feeding, growing, dividing, and so multiplying. We have also dealt with cells of which organisations are built up, and with the specialised cells or eggs which, obeying the law of heredity, build them. We now therefore come to the laws of variation and progress.

The laws of variation and progress.—Gradually by these laws amœbæ came into being, infusoria, worms, insects, star-fish, shell-fish, spiders, fish, birds, quadrupeds, and men. By the law of variation alone, protoplasm would have produced protoplasm in great variety, but it would only have been protoplasm. Cells, if they had in some way been brought into being, would have yielded varieties of cells. Infusoria, worms, and every kind of animal would have yielded varieties of their own kind. But the variations made advances. The forces at work carried them forward to higher and ever more complicated variations, until they culminated in the highest, with their myriads of wonders. This course of evolution, as we contemplate it, is of overmastering grandeur. The bodies it exhibits to us, the individual organs it presents to our view, the triumphs it sets before our eyes, no language can do justice to. All over the fields of life there has been a determined and uninterrupted march forward. Onward and upward has been the motto of nature, onward to greater complexity, upward to higher excellency. It does not appear that the weaker which perished were monstrosities. There is no reason to believe that evolution advanced in millions of wrong directions, along centillions of unfit lines, and by chance discovered the right line. Like the combinations of chemistry, its products have been useful and good, splendid in proportion and elegant in form. The onward march to the

grass of the field, the lily, the rose, the orchid, the trees of the forest, the vine, the fig-tree, and all fruit trees, was from the beginning, though slower, yet as regular and beautiful and ordered as is now the growth of the grass, the lily, the rose, and all fruit trees. The onward march to the lark, the eagle, the dog, the horse was as regular as is now the development of these forms of life. The advances in the history of evolution did not form a vast chaos, in which were centillions of failures, but in which by chance one fitting and worthy form of life appeared. They formed a scene of ordered and fitting, though not always the strongest, forms of life. In short, their evolution from the beginning was toward the good. An eye resting on them at every stage would have pronounced them very good. A scientist, if he could have lived and examined the world of life at every stage of its history, would have been able to affirm that then, as now, law reigned; that then, as now, the whole action of nature was ordered action. What, then, meaneth this tendency so masterful to ordered progress, this obedience to law and exclusion of chance? Why were the forms of life evolved from the beginning in so overwhelming a measure, such as commend themselves to a seeing and understanding mind? Why was the evolution of the lily and the rose, the lion and the ox, as regular as is now their development from seed and egg? Why has phylogeny been as beautiful as ontogeny? Why have the forces of nature advanced through the millions of years with patient steadiness as if knowing the end from the beginning; as a man, turning not east nor west, north nor south, or in any chance direction, but making straight for a chosen goal; as a ship, not wandering whithersoever winds and currents may carry her, but guided over thousands of miles to a determined haven? Why at

every stage were material and living elements able to work and to weave and build up nothing but the ordered and the good? Why, but because of the perfection of their own order. Why, but because of the carefully measured and balanced potencies in themselves, measured and balanced by mind to obey a law of ordered progress, even as now to obey a law of ordered growth. If there be mind, as we have seen, in the building up of animal frames, much more is mind necessary in steady and regular advances, marching forward through vast periods of years.

The struggle for existence.—The struggle for existence, the survival of the fittest, and natural selection are the various names given to the law which is Darwin's glory. It is determined by environment. It is on environment that everything involved in its action depends. Environment makes the struggle. Environment kills. Environment selects, preserves, and maintains. From the beginning of evolution, onward through its whole course, environment determined the variations which should survive. Environment includes physical conditions, abundance or scarcity of food, enemies and friends of every kind and nature. At every point, in every stage, a variation suited to the physical conditions, finding sufficiency of food, finding itself stronger than its enemies, survived and propagated its kind. Times of special sifting intervened, the physical conditions became severe, food became scarce, and enemies multiplied, and so all feeble varieties were destroyed, while only the very strongest remained. There have been in the history of the earth times of overpowering heat, times of overwhelming cold, times when scarcity of food prevailed, times when enemies and hostile influences multiplied. But, on the whole, during the millions of years throughout which evolution has

been proceeding, environment has played a beneficent part. It has killed off feeblenesses, and preserved the strong, the well formed, and the worthy. It has nursed improvements and carried them forward. In its times of greatest severity and stress of physical conditions it has not, as it might have done, slain all the children dependent upon it. In its times of greatest scarcity of food it has left sufficiency for a chosen remnant. When enemies most prevailed, they never became so numerous and powerful as to slay a large portion of the species. It has acted throughout as with wisdom and discretion. Its very severities braced, strengthened, and improved the children of its choice. Why has environment acted in a manner so ordered? Why has it tended to preserve useful variations? How has it been able to produce an animal world so characterised by usefulness, suitableness, and beauty? Why has it co-operated with the life element so perfectly? Why, but because it has itself been ordered and guided. It has been as a mighty mould, moulding and fashioning all living things. It has been as if carefully devised from beginning to end for the purpose.

The subject of environment thus leads us back to evolution in another field—the evolution of the universe of worlds. All form a unity. All hang together. All form part of the environment, and have their part in its action. And if they have been evolved out of material elements scattered through immensity, this work like that of the evolution of life has been accomplished in a manner transcendently glorious. In size and form, in collocation and condition, we behold in them order on the grandest scale. And on this condition of order being brought about depended the evolution of life, on any individual world depended the vast environment far and near all around the earth, round its living forms, of which

we have spoken. And so the evolution of living forms on the earth hung on the ordered condition of matter in the earth, on its suitableness for producing and nourishing life, on the ordered condition of matter in the universe, on an amount of order inexpressibly vast.

If, then, the vegetable and animal world have reached their present condition by evolution, the evidence that mind has been behind the scene, as the first and original cause of, and preparing for, every step and every advance, taking every step, making every advance, is overwhelming. From the foundation to the top stone, from the first and simplest combination to the completed and complex structure, working after the manner of intelligence is seen. Everywhere there shines the hand of inimitable mind. The evolved world is not a daub or a blotch, or as any work done by a man in darkness and ignorance. It is not as if millions of men were to bring stones unknown to each other, and blindly fling them on a field in any direction. No gem of architecture, no building of any kind, rises as the fruit of such work. In the evolution of protoplasm and ovules, in their building up of living forms, there is no irregularity, no bungling, no working as in the dark, no groping, no sign as of an unskilful hand. There is perfect law, there is a regular course and manner of progress, a measured, skilled, trained, onward march to a goal. At no point is there the sign of the hand of chance, but everywhere of mind. It is as in a great ribbon manufactory, where silk threads pass to and fro, and are skilfully mixed for the production of patterns. It is not the whole matter to know how the threads are arranged, and the modes of working for the production of the pattern. We ask, Why are the threads in their ordered places? How came they to be so disposed as to form beautiful patterns? Why are all

the threads of the same constitution and measured? Whence the carefully constructed machinery, and the force applied to it? And so it is not enough to tell us in what way the frames, and forms, and tissues, and patterns of the animal world have been woven. That explains the most insignificant part of the work done. The great thing to be accounted for is the existence of the material, its suitableness, its position, qualities, and forces. And to account for it, we must go back to the foundation elements, and finding in them the potencies of all that is evolved, ascribe them to mind.

The sufficient time element.—"Carneades," says Cicero, "imagined that in the quarries at Chios he found in a stone that was split up the representation of the head of a little Pan, or sylvan deity. I believe he might find a figure not unlike, but surely not such a one as you would say had been formed by an excellent sculptor such as Scopas. Colours thrown upon canvas without design may have some resemblance to a human face, but do you think they would make as beautiful a picture as the Coan Venus? For so verily the case is that chance never perfectly imitates design." Colours thrown by chance on canvas by unskilful and unpractised hands would not, in eternal ages, produce a perfect picture. Were all the hands now on earth to make the trial, does anyone doubt what the result would be? There would not be one gem among all. Would another generation succeed better? Would any generation for ever succeed better? No, not any. As the result of pure chance a Coan Venus or a Madonna would never be seen. To chance such results are impossible. Ah! what foolery is it to dream that a mighty world has been produced by chance—a world shining with glories of mind as much surpassing those that beam in beauty from the loveliest human face as

the sun outshines a burning rush, — what foolery is it to dream that chance could achieve triumphs so transcendent even in an eternity. The time element in evolution only adds to the wonder and the difficulty and the strength of the demand for the presence and action of mind. Were a painter or sculptor to live for a thousand years, and devote himself to the production of a painting, or *chef-d'œuvres* of sculpture, formed of myriads of parts, every part a matchless gem, and all forming one whole that should seem to live and move, would not his completed work evidence a whole world of thought and care? The species of animated nature are many. Each is crammed with a wealth of the finest work. Each is the result of operations carried on through ages of ages. Every touch, every minutest step in the advance is a stroke of matchless genius, was produced by the joint action of multitudinous ordered elements, and an environment on the vastest scale. The whole work from beginning to end, and at every point, is not merely like that of a painter or sculptor working patiently and skilfully through centuries, but infinitely surpasses it, and therefore proclaims more loudly and clearly, proclaims as with the sound of a mighty chorus, that it is due to an understanding of incomparable glory.

Consider the earth at the present time, its form, its size, its particles, their multitudes, their chemical properties, the ether and its relations to them, the forms of life in flora and fauna, and are we not overmastered by the riches of order and qualities and powers that are in them? Go back as far as we please, material elements and the potencies of life were so conditioned, collocated, and environed as that, after the evolutions of ages of ages, every particle should be in the condition which it

occupies at the present moment, should be executing the motions, showing the qualities, doing the work, and rendering the services which it is now rendering. During the mightiest conceivable interval it has not been a moment still. It has changed its place, its action, and certain numbers of its motions, times without number; but there has not been a change, there has not been an activity, according to the theory of evolution, that was not in it and its environment, at any point in its past history. And the whole matter of the globe, if it existed a hundred million years ago, was in such a form and state as naturally and necessarily to be evolved into the condition with which we are familiar. It was so ordered, collocated, and characterised, as to be naturally developed into the atoms of the seventy elements, into their compounds, into protoplasm and all that it builds up. It was a scene of order, therefore, as remarkable as what has come out of it, and therefore demanding an explanation as much as do the complex arrangements and organisations which now open so extensive fields for study. We have therefore to account not merely for a scene of vast and complicated order, existing at any moment, but a scene constantly shifting for millions of years, constantly advancing, and at every point in its history making straight, as if guided by mind for its present glories. The same is true of all the matter of the sun's system, of all the matter of the universe. The universe is a scene of order. At every point in its history it has been a scene of order. It is now shining brilliantly with the work of mind. At every period in the history of its evolution it has been so shining. It has passed through changes innumerable, but every change has been according to law. There have been operations on the vastest scale, and operations most minute, but every operation

has been according to order. If we contemplate the changings, workings, advancings, if with the most enlarged imagining we survey evolving elements in their grand march forward, if we call up before our mind the perfection of order in their motions and actings, from their circumference to their core, from ancient ages to the time now present, are we not compelled to admit that they shine with a light infinitely dazzling, are we not overpowered with awe as in the presence of a mind of all-transcending power?

Evolutionists say, that were their doctrine false, were the phenomena on which they rely for its proof nothing better than lying signs, all the interest of nature studies would be dissipated. Geologists say, that if the strata, which they find in the crust of the earth, do not deliver a true message as to their formation, if, notwithstanding phenomena whose natural meaning is so different, they were created and laid down at the same moment, all the fascination of geology would disappear. With immeasurably greater justice and force may we say, that, if animated forms produced by fitting and patient advances through millenniums of years be not the work of mind, if the signs of its operation in them be but lying wonders, if, notwithstanding their multitude and force and brilliancy, mind had no part in their production, then all the interest and fascination of evolution itself, and of the sciences illustrated in it, are dissipated and disappear. For surely the interest of every science is to the human mind an intellectual interest. Their fascination lies in the marvellous order they reveal. Their enchantment proceeds from wondrous laws, marvellous arrangements, from the signs of mind with which nature is so radiant. And if these are only a deceit and a snare, if the most wonderful and striking

phenomena that are be but a mockery and laughter in our faces, what can we do but turn away from them with abhorrence and contempt? But we cannot think thus meanly of them. If we did so for a moment, and turned toward them again and looked them in the face, they would be more than conquerors over us, they would make us ashamed of our thoughts. We cannot but think nobly of their nature and birth. Their simplicity and transparent honesty, their beauty and power, render it impossible not to believe their clear and unimpeachable testimony to the source of their existence.

XI

CONCLUSION

Material Elements ordered not by Necessity, not by Chance, but by Mind—Primal Elements ordered—Made and Created—All Things ordered by Infinite Power and Wisdom.

We shall now endeavour to show to what the whole matter tends, to what conclusion it leads us. For this purpose we observe—That matter and its properties cannot have necessity as the ground of their being.

The number of the atoms of each element is enormous. There are billions of them within the smallest space. In the universe there are worlds of them. But within, say, our sun's system, there must be a finite and definite number of each kind. There must be x atoms of oxygen, y of carbon, z, a, b, c of other substances. It cannot, we say, be of absolute necessity that of oxygen the number x should be found in the space supposed, of absolute necessity that there should have been neither more nor less. It cannot be of absolute necessity that of carbon there should be found the number y, and of other substances the number z, a, b, c, d. No sane mind can for a moment imagine that from the nature of things it was an eternal necessity that the seventy, or thereby, different kinds of atoms, should all exist, or be formed in the numbers, and proportion of numbers, in which they help to form our great system obeying the orb of day.

When also we consider the atoms as they are, and the

conditions and laws of their action revealed by science, we see them, in their every individual, radiant with signs of mind. In themselves they are material, but on them, in their form and characteristics, the image and superscription of mind are unmistakably stamped, show themselves not dimly, not as on a coin old and worn, but as on one fresh from the mint, as on one ever new, and that never, by any amount of use, loses its brilliancy or clearness of outline. It is impossible therefore to ascribe them to any unintelligent principle. It is impossible to find a ground of their being, as they are in a blind physical necessity.

The idea of relationship between separate entities excludes the idea of necessity, and implies the operation of chance or mind. A relationship is a correspondence, or state of adaptation, between the qualities and powers of two distinct objects. There is nothing in the idea of necessity as a cause to make them correspond with each other, to produce a state of adaptation between them. There is nothing in the idea of necessity to create relationship, or any reference to each other. Take an atom of carbon and one of oxygen. Both suppose have existed from eternity. They exist of themselves. It cannot be said that they made themselves, but simply that they exist of themselves and have their characteristics of themselves, each independently of any external entity. In this ground of their being there was nothing necessarily making them different from each other, and necessarily adapting them for each other. A blind physical necessity could not, being blind, necessarily establish relationship between them. If relationship exist, it must on the supposition of eternity be due to chance. If only a small number of atoms thus related to each other existed, we might be unable to draw any other conclusion. But if the relationships are so many,

and of so marvellous a nature, if every atom that is, is so constituted as to have relations and clear and unmistakable reference to other atoms, it is rendered impossible to ascribe them to chance. No healthy understanding can do anything but acknowledge that they are due to mind. In short, eternity and chance are here indissolubly joined together, and when chance is excluded, eternity also is excluded, and mind enters.

In bringing about relationship between eternal atoms, chance cannot be conceived of as having any sphere of action. We can imagine it doing something in forming collocations of atoms in motion, but what part can it have played in bringing about adaptation among independent and unchangeable atoms, before all supposed motion? It might go a very little way in producing order among existences, mingling, acting, and reacting on each other. But how or where could it find any place in producing order that must be conceived of as existing before mingling, acting, and reacting began? The atoms must have been as they are, before there could be any opportunity for chance doing aught.

According to the doctrine of chances, the greater the number of independent characteristics that meet together for the production of a particular result the stronger is the evidence that their meeting and the result are due not to chance but to mind. Every additional characteristic adds greatly to the strength of the evidence, increases it according to a rapid multiple proportion. Sixteen contingencies meeting are immeasurably stronger than four, and sixteen times sixteen are overwhelming. Two dice, shaken, and showing the same sides thrice would surprise, but if it were to occur ten or twenty times, no one would hesitate to ascribe it to an arrangement causing such a result. Between two atoms of, say, hydrogen

and chlorine there are several adaptations and relations and as many contingencies. Both have the atomic nature, form, and force. These are with inexpressible accuracy and minuteness adapted to each other. They unite to form a molecule possessed of new properties. Here are contingencies strongly suggestive of mind. And the argument is not merely a little but greatly strengthened, when we find another atom of each, in which the same properties and the same results of union are found, and the same contingencies are involved. When we reach ten of each, or twenty, or a hundred, it becomes of inconceivable force. But the numbers and contingencies go beyond all bounds, and the idea of chance as accounting for their state is chased and driven to a distance beyond all bounds, and is absolutely excluded. But chlorine, as we have seen, has all its atoms adjusted, not to hydrogen alone, but to all the elements, and in every case the same argument may be advanced, and with the same overwhelming force. And taking into account, and adding the multitude of affinities between elements and elements, elements and compounds, compounds and compounds, the relationships of the molecules to the ether, and all the outcome from them in the many forms of life, we slay the slain ten thousand thousand times, we strengthen by centillions of bulwarks the building already strong as the eternal rock.

On the supposition that the order existing among the elements of matter is due to mind, how great that mind must be. The perfection of the adjustments, the complexities and extent and amount of arrangements, are such as to demand in the intelligence producing them power immeasurably beyond all bounds that imagination can conceive. He who could devise in thought, and realise in fact, the vast and intricate system of the

material world, who could make it so rich in beauty, who could put into it so extraordinary a wealth of order, who could make it throughout all its borders, in every, even the smallest portion of its extensive territories, such as to create a boundless enthusiasm of admiration, must be as far above the sons of men in understanding as the most distant star from which it takes light thousands of years to come is above the earth. The union of suns and planets and moons, of clusters and galaxies and nebulæ, is set in an order that declares the glory of the wisdom of Him who built them and appointed them their place. But the glory of wisdom which they proclaim is not to be compared with the glory, is almost infinitesimally small compared with the glory displayed in the universe of atoms. Can then order so amazing be referred to chance? Can that which is worthy of a mind so far transcending all measures of power be the work of, or have as the ground of its being, any unintelligent principle? Can triumphs, which demand for their achieving the understanding of a God, be ascribed to any blind nonentity? They cannot, they cannot. Any such suggestion is an insult to the poorest understanding.

Because of the forces of matter Herbert Spencer admits that there must exist an infinite and eternal force. The universe is abundantly charged with force. It is everywhere, at every point. Many and great are the varieties of it. There is the force of gravity, that in its might binds suns and systems together, and at the same time determines the fall of a feather and the weight of an atom. There are heat energies, which in the sun rage as in a furnace thousand of billions of miles in extent, hundreds of thousands of miles deep, and send forth swift messengers to fall gently on, and minister to, the

earth. There are the forces of affinity, of cohesion, of adhesion, that bind atom to atom, particle to particle. There is the force of elasticity, that makes light to shine, heat to travel, and music to sound. There are the forces in steam and electricity which man has harnessed to his chariot wheels. But force is not everything. It does not occupy the whole field of existence. It is not the greatest thing that we know. It is not of highest rank, and lord of all. Weights, energies, affinities, elasticities, and electricities do not reign supreme and swallow up all besides. Nay verily. Do we not know things of higher rank? Is not mind higher? Is it not of wider sweep? Is not every form of force, if on the earth or in the sun, in its hand, as in the hand of its greater, its higher, its master, bridling it, meting it out, guiding its operations, and teaching it its ordinances. Can a mere force see, and set in order; an infinite and eternal force of which nothing more can be said, produce and carry on this ordered scene on which attention is demanded to things on the greatest scale and in minutest detail? If so, then may we expect to plant a stone and from a tree of its growth, to pluck the fruit, to light the furnace, dissolve the iron, and see springing forth letters that shall arrange themselves into works greater than Plato and Shakespeare ever penned. There is an infinite and eternal force to which all things are due, but it is an infinite and eternal force at the command of an infinite and eternal Mind.

The atoms of matter are made, but it may be said that their present condition has existed only for a time, and that the seventy elements have been formed out of elements still simpler. There may not exist at present the means by which to produce a separation, but they may be separable. Such an allegation cannot be denied.

But the fewer the absolutely simple elements may be supposed to be, the more richly must they be endowed. To the multitude of adaptations and adjustments which we have already found must be added the number necessary to produce the present seventy. And thus, if there be only twenty, or ten, or five, or even two, all that we brought forward showing the order in the formation of compounds by innumerable combinations among the seventy continues applicable to them, and applicable also to the unions formed from the two.

But it is said that there may be only one primal element. In this case all the particles are alike. It must have consisted of particles in some form. It must have been an element naturally divisible and separable, otherwise it could never by any means have been divided, and parts separated from parts to form aggregations or combinations. And we say that, on this supposition, they were alike, were of the same figure, size, and weight, and were endowed with the same forces and capacities. And the argument we have advanced from likeness becomes in their case of greater weight in proportion to the greater number of atoms alike, in proportion to the greater wonderfulness of their constitution. The atoms of carbon, oxygen, hydrogen, and nitrogen are wonderful exceedingly, but they are as nothing compared with the atoms out of which, on this supposition, the whole physical, chemical, and living world has been evolved. Nothing can come out of any entity which is not in it. It cannot yield a multitude of variations unless they belong to its fundamental nature, ready for development. And so if there be but one simple kind of original particle, and there have come from it all the variations with which we are familiar, what must that particle be? All the variety in the universe must be hidden in it.

Can anyone then ascribe the likeness of gems so rich and multitudinous to chance? Chance could not have given us twenty atoms so constituted and so similar. Possession by chance of forces and characteristics so extraordinary in their nature, so perfectly similar and so exactly measured, so exquisitely adapted and so richly adaptable, is an absolutely impossible suggestion. Every particle, and all the particles, with one voice sounding everywhere through immensity, inexpressible in beauty, clearness, and force, protest against the madness that would bring it forward.

The atoms of matter, whether of one or many kinds, have not been formed by mere division. In such a case the matter divided must have been naturally divisible into such atoms of their size and weight and nature, it must have been composed of aggregates of them; and then the question reverts to the same position as before, for they must all have existed from eternity in the same condition as now, though under a different general arrangement. They are not formed by mere aggregation. That would imply the existence from eternity of atoms of a smaller size, but of the same nature and constitution, and therefore having the atomic form, and all the possibilities of their present condition. It would imply that those atoms of smaller size happened to be of such measures and figures as to be capable of being formed by mind into units the exact counterparts of each other. It would imply that they possessed the same characteristics as the aggregates now possess, and that they had in them the power of acting as the aggregates now act. It would necessitate their having the characteristic of a strong force of cohesion. The existence of this force between two independent particles was a contingency. It was pure chance that there should be an attraction between

them of so fine a nature, and capable of binding them together so firmly and so closely that instead of acting independently they act as one. In this form the contingencies are as wonderful, and are more numerous than on the supposition of the simplicity of the atoms as they now are.

If they are the product of chemical combination, if they are ascribed to it, they only, we have seen, multiply the signs on them of mind, they only afford a larger field for the argument that they are its work.

They are not developed by all processes combined out of a chaos of matter. What has made it possible for minds possessed of reason to believe that the universe and its order, the earth and its wonderful organisms and forms of life, have been gradually evolved out of primitive matter? What made it possible for some of the ancients to imagine that all things could be accounted for by a fortuitous concourse of atoms? Because without acknowledging it or clearly seeing it themselves, they postulated the existence of matter in an ordered condition, and endowed with the riches of its varied and measured properties. If matter, in its primal elements, had been supposed to be a real chaos, without order or relationship of parts, without measured properties, how could it have been imagined that the most beautiful and wonderful organisations could be produced by its action? Evolution necessarily supposes order and measured potencies in the materials which work in it. Chaos can neither evolve itself, nor can it be evolved. Disorder can neither develop itself, nor can it be developed.

It cannot develop itself. If the primal elements of matter had been in all respects inert, without atomic form and force, without the forces of gravity and cohesion and many wonderful characteristics besides, they could not

have evolved themselves into a glorious universe. Inert matter, empty of potency, could not have become a fountain of power. Atoms without likeness or relationship, atoms without the atomic nature, could not have developed into chemical combinations. It is because in the world we are face to face with matter in an ordered condition, with vast amounts of the same and of various kinds, with those amounts marvellously characterised by relationships, endowed with wonderful powers mingled together, and everywhere as of themselves bringing their powers into play, that anyone has been able to imagine that the world is self-evolved.

By mere arrangement of materials mind could not have evolved a kosmos out of a chaos, or brought order out of disorder. No human mind, though possessed of the most brilliant genius, though endowed with the mightiest power of arrangement, could form the simplest instrument without materials suitable for the purpose. If then we ascribe to the mind which built up the universe, not an infinite and creative power, but only the power of arranging materials, it is evident that out of no chaos, out of no realm knowing only disorder, could He have called it forth. By arrangement only the order that exists can be made to show itself. For arrangement there must be substances capable of being arranged, needing only collocation to produce the results. Who can produce order where order there is none? Out of an element void of any quality, who can make that quality to spring? Out of any entity who can bring that which is not already in its nature? No finite mind can by arrangement do these things.

The primal particles are the work of mind. Whatever may have been the primal condition of matter, whatsoever supposition we may form as of fluidity, or any mode

of existence, it must have been naturally divisible into particles, and therefore composed of them, into particles having in them the ordered potencies revealed in the evolutions from them, and therefore we say the work of mind. But if they lie at the very foundation, are perfectly simple, and yet are the work of mind, they must be so by creation. No other alternative is left. Mind must have given them their being.

Suppose a finite mind in the beginning seeking eternal matter within His sphere. The question was, Should He find it? Should He find it in sufficient quantity? Should He find it in a state of chaos even? There might have been but an insignificant mass at a point in space. It was a pure chance that even it should exist. It was a pure chance that many masses or one of large size should have being. The chances were countless against the amount existing in the universe being found. The supposition therefore of a chaos, even of matter, having being in the immensity of space, and a finite and relative being existing, not at an infinite distance from it, but in the same space, and through relationship to it able to build it up into the kosmos we know, is one which the rational mind cannot for a moment entertain. The force of these considerations is increased in an enormous measure when we take into account the wonderful, multitudinous, and varied characteristics of the material world, and specially if we affirm that life and every faculty in living natures is an evolution from it. And if vitality and mind are elements, then that so vast an amount of different elements capable of being brought together into beautiful working order should have existed by chance from eternity, is absolutely impossible.

Creation demands infinite power. If I reach the fact

of creation, said Dr. Duncan, I reach the Infinite, for the Infinite power alone is creative. (1) Creation demands infinite perceptive power. He who can give a particle existence must be able to perceive any measure of smallness. He sees it through its whole being and in its every characteristic. His hand has touched through all its borders, has touched its every point down to a point infinitesimally small and bordering on nothing. There is no smallness however small which He cannot perceive. There is therefore no limit to His perceptive power. (2) Every particle is of a relative nature and size. Its measures to a related perceiving nature depend on the perceptive power of that nature. But to Him who created it, it must appear and be known absolutely. He must therefore be of an absolute nature. (3) Creation demands infinite power of will. Between nothing and any solid magnitude, any real existence, the distance is infinite, and to create something where before there was nothing is to bridge that distance. No merely relative power is equal to this work. It demands the energy of an absolute nature. (4) Creative power is supremely, is ideally great. No greater is possible. In calling into being that which before was not, power does its utmost. It rises to the loftiest height. Higher power cannot go. No greater work can be done than it accomplisheth. None harder can be conceived. It is independent. It needs no external aid. It is absolute. It does not act on forms of being because it happens to be exactly related to them. It produces its own forms.

Our mode of argument, even on the contention that the universe was built up out of pre-existing materials, leads to the conclusion that its architect and builder is infinite and absolute. We have shown that for inter-

action, atom is related to atom, and to the ether, and the perceiving nature to both; and that the relationships are so many and the adjustments of so fine and so remarkable a nature, that they cannot be ascribed to chance but to mind. Let us suppose then that the Author of the great kosmos, instead of being infinite and absolute, had relationships to material entities and perceiving natures, enabling Him to use them to purpose. He had perceptive power capable of perceiving atoms and molecules and their properties in their fineness and extraordinary potencies; perceiving natures in their fineness and still more extraordinary powers. He had also the power of laying hold of and acting on them, of arranging them according to their relationships and bringing their capacities into play. He thus had relationships to three different kinds of entities, in the multitudes of the relationships, and in the quantities of the entities which we know. The power to perceive and act on one atom demanded the nicest adjustments to it, on all atoms the nicest adjustments to each and all, and so in the case of the ether and perceiving natures. All the perceiving natures that have ever been or now are, with their related capacities adjusted for perceiving and acting on material elements, show comparatively but a few poor relationships and adjustments beside the number and grandeur of those in the mighty mind which built up the heavens and the earth and the organisations and forms of life within their borders. Instead, therefore, of accounting for the phenomena of the universe by ascribing them to a finite and related being, possessing limited powers adjusted to material elements and perceptive powers, and so rendered capable of acting on them, we multiply indefinitely the phenomena demanding explanation, and so greatly increase the necessity for the existence of an

intelligent cause to account for them. We add to the multitude of relationships between the three kinds of entities a still greater number between them and a fourth, and therefore requiring a fifth to produce them. And if the fifth be of the same nature, much more is a sixth required. And the farther we advance the requirement grows. We are thus led to the conclusion that the former of all things cannot be finite and relative, and happening to exist from eternity of a constitution so richly related and adjusted to three other entities as to be able to act on them in an infinite variety of ways, but must be infinite and absolute and able to act on any nature and in any way whatever.

A finite and related Maker or Builder of the universe would have been entirely dependent on chance. He could have done nothing of Himself. He could have done nothing without finding material elements and perceiving natures, ordered and related to each other, and to His own powers, or in such a condition that His own related powers could bring them into order and relationship to each other. It was a matter of chance that He should find a single particle of matter or ether point or perceiving nature anywhere within His range or limited sphere of action. It was a matter of contingencies without number that He should find primal elements sufficient to form the least drop of water, the least grain of sand. How inconceivably vast the multitude of contingencies involved in His finding them in quantities sufficient for being built up into a world filled with organisations and perceiving natures. The dependence on chance, therefore, of such a being would have been immeasurably, yea, infinitely great. Chance would have played the all-important part, and the chances against would have been, not merely as the number of

atoms, ether points, and perceiving natures, but as these multiplied indefinitely. The conclusion, therefore, is inevitable that the Architect and Builder of the universe is not of limited and related powers, but unlimited and absolute.

PRINTED BY MORRISON AND GIBB LIMITED, EDINBURGH.